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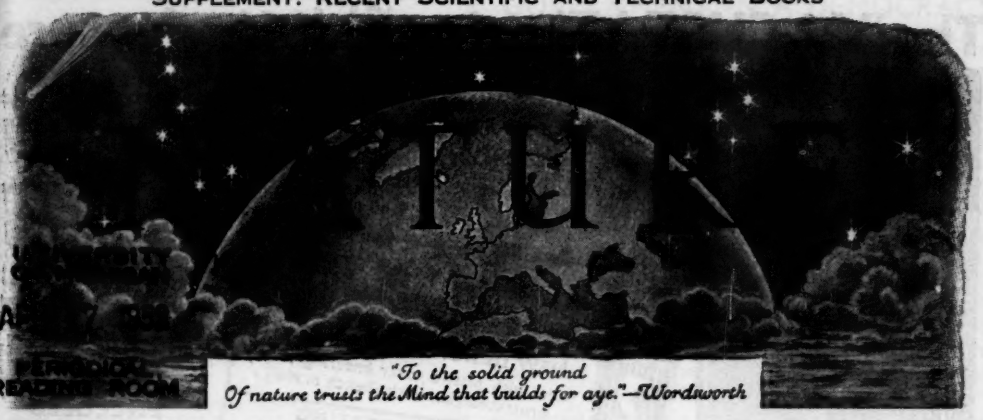

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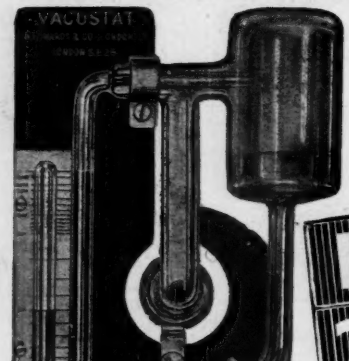

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GOVERNMENT IN A DEMOCRACY

IT has not yet been made known whether the present Government is continuing the Cabinet Committee on the Machinery of Government and, if so, whether it will reverse the decision of its predecessor and publish the reports of that Committee. Quite apart, however, from certain changes in departmental functions and groupings, Mr. Churchill's Government will clearly have to give some hard thought to the broad problems of the organization of government and the underlying functions of government in the State and economy which Mr. Churchill and his followers envisage. The fact that such an examination might lead to savings in man-power is a minor consideration, though a welcome one. More important is the bearing of the question on the efficiency of the Civil Service and of the nationalized industries ; and at a time of crisis any measure that could contribute to the safeguarding of individual liberties, the encouragement of initiative and enterprise should be examined to the full.

Two moves have, in fact, already been made by the Government. In November a select committee of the House of Commons was appointed : "To consider the present methods by which the House of Commons is informed of the affairs of the nationalized industries and to report what changes, having regard to the provisions laid down by Parliament in the relevant statutes, may be desirable in these methods". It is now realized that coal, electricity, distribution and transport are too important and affect the public too directly to be kept out of politics in the same way as the British Broadcasting Corporation or the Forestry Commission. The temporary arrangement of leaving some discretion to the Speaker of the House of Commons as to the legitimate scope of Parliamentary questions has in practice worked fairly well, but a fresh attempt to lay down general rules on this matter is desirable.

The question of the nationalized industries, however, can scarcely be left there. The 'standstill' arrangements in regard to steel and transport afford the Government the opportunity of thinking out more fully the broad question of the future organization of the nationalized industries. Even the strongest advocates of nationalization no longer suggest that any one type of structure is suitable for all the varied range of industries now affected. Already the Acton Society Trust is conducting valuable studies into the working of the nationalized industries and the practical problems encountered, which should provide much useful material ; and others also have reviewed the situation.

The need for further inquiry and for hard thinking on this question is widely admitted ; and it will have been noted (see *Nature*, Feb. 23, p. 320) that, in commenting on Lord Cherwell's suggestion in the House of Lords on July 5 that the development of atomic energy should be removed from Civil Service control and placed under some more flexible form of organization, Prof. H. W. B. Skinner urged that it is still not clear, in detail, what would be the best form of organization for obtaining clear decisions on

technical policy and the most efficient implementation of the work. Two years ago, in lectures delivered to the University of Manchester, and since published under the title "Reflections on the Constitution", the late Prof. H. J. Laski emphasized that the problem of Parliamentary control of the nationalized industries itself would require careful thought, even if there were no considerable extension of nationalization. His own suggestion, intended to make Parliamentary control effective and not merely formal, as well as to stimulate public interest in the industries and to prevent public control slipping into bureaucratic habits, was a series of standing committees in the House of Commons, one for each of the industries concerned. These committees, each of which would be provided with a small but highly expert secretariat, would examine the annual report of the particular industry and would be fully empowered to summon witnesses or to take written evidence. They would finally report to the House of Commons.

The suggestion merits discussion; but while it may be a practicable proposal at the moment, extension of nationalization on the scale which Prof. Laski himself contemplated could easily make it unmanageable and reduce parliamentary control to the present formality. Even if the industries proved, in practice, to be so efficiently run that little examination of witnesses was necessary, there would still be a considerable tax on man-power, not least on the time of members of Parliament. That in itself could have repercussions on what is already a full-time occupation for many; but Prof. Laski's proposal ignores the fundamental question to which inquiries like those of the Acton Society Trust have directed attention. He assumes that we have already found the most appropriate type of body for public control of industry. The studies already published by the Acton Society Trust suggest at least serious doubts as to whether we have yet found either the right form of organization, the appropriate balance between centralization and decentralization, or even succeeded in staffing the various national boards themselves satisfactorily.

At least it seems clear that no one type of organization is likely to prove satisfactory, even for the varying types of industry already nationalized; and prudence would suggest that experience be carefully and impartially examined before any steps are taken to extend nationalization further. There seems sufficient agreement on this to hope that such an examination can be carried out independently of party politics, and that the Parliamentary committee considering the question may succeed in providing a solution generally acceptable. That could at any rate prepare the way for an impartial and fundamental study of the wider issues.

The second move made by the Government is the promise given in the debate on the renewal of the Supplies and Services Act to make a thorough review of all emergency powers. Some few powers are being allowed to lapse, and others may be abolished during the present session. Others again, which may be needed for some time, will be embodied in legislation requiring annual renewal. A few will be included in permanent legislation.

This attitude, on the face of it, is correct; but before the Act comes up again, there should be a really serious and thorough review of the powers of the State. For this purpose an authoritative committee—and not a committee of Civil servants, whose desire to speed up administration by dispensing with the usual processes of legislation is a main factor in the proliferation of vague powers—should examine every new power that has been conferred on any government department since April 1, 1939, other than those powers that have already been embodied in permanent and specific statutes. The right questions to be asked in respect of every such power are obvious and have been well indicated by *The Economist*: Is the object for which power was sought a necessary one? If so, can it be achieved by some means other than giving officials law-making powers? Are the powers sufficiently defined and restricted to their purpose? Are there adequate provisions against arbitrary exercise?

Such an examination would undoubtedly lead to the elimination of many of the existing powers, and the remainder could be arranged in two categories: those that are permanently necessary, and those that are needed only for the duration of the re-armament emergency. The former should, as soon as possible, be embodied in permanent statutes, where their purpose and use can be adequately defined and safeguards can be provided for the rights of the citizen. It should be axiomatic that no permanent power should be undefined, and no undefined power should be permanent.

This point eluded Prof. Laski in the lectures already noted, when he discussed this question of delegated powers. That departments have sometimes abused their powers cannot be denied, nor is it in dispute that delegated legislation is to some extent inescapable. It is not suggested, as Prof. Laski seemed inclined to believe, by those who are concerned at this tendency in government, that departments are seeking to abuse the powers that are put into their hand. It is, however, maintained, and with justice, that there is an unhealthy and undesirable tendency to consult administrative convenience rather than the liberty or convenience of the subject; and such an inquiry as that indicated above would help to shatter official complacency, which, without subservience of some such principle, may easily slide into those very bureaucratic habits which Prof. Laski was most anxious to avoid in the nationalized industries.

Some observations by Mr. A. W. Juke in his recent chairman's address to Barclay's Bank, Ltd., are worth recalling in this connexion. Speaking on the role of authority, while recognizing the inevitability of certain forms of State intervention in our economic life, Mr. Juke affirmed his disbelief in the efficacy of any central control of all the manifold wants of fifty million people by means of permits, coupons, and licences; for they are no longer considered merely as necessary evils, to be tolerated in time of war and other grave crisis and to be abolished as soon as

possible when the crisis is ended, but as weapons with which to repress the anti-social tendencies of those who wish to spend their own money in their own way. Mr. Juke is convinced that in this sphere authority should confine itself to avoiding the creation of conditions in which it pays a man to break the law. Human nature being what it is, it is useless to depend on regulations which can be evaded and on appeals to the social conscience which can be ignored; and Mr. Juke frankly but realistically holds over-planning and over-taxation largely responsible for the deterioration in many directions of the moral standards of the people of Great Britain since the end of the War.

Mr. Juke's reminder that we have as yet found no alternative to money for giving the consumer the same freedom of choice might have been phrased less controversially, but the points he makes are fundamental in any real review of the organization of government at any level. Some at least of our difficulties arise from the neglect of a precept which Prof. Laski once laid down, but which in his lectures he seemed to have forgotten: the channels of assent can rarely be dug too deep in any legislative or administrative matter. Too often in these days little or no attempt has been made to gain the understanding of the public affected, and there are details in the latest economy proposals of the Chancellor of the Exchequer which suggest that even yet the importance of this matter has not been fully grasped—for example, in what was said regarding the reduction of the Civil Service.

The size of the Civil Service is determined by the magnitude of the duties thrust upon it by the Government and the public opinion of the day. Its post-war expansion is a direct result of the expansion of the task and functions of government during the past six years. The first step to a reduction in the size of the Civil Service is a fundamental review of the functions of government. Having decided on those functions and the way in which their discharge should be organized, the way is clear to decide what reduction in staff is possible without detriment to the efficient conduct of the task of government.

The reason Mr. Butler gave for not introducing the rationing of petrol indicates that this is appreciated to some extent by the Government, but neither political party has yet had the courage to put the issue frankly before the nation and to point out that the steady expansion of the responsibilities of the central government through social welfare measures, nationalization of industry and in other ways has meant the steady diversion of resources of man-power from productive work to administrative duties. That tendency can only be checked by a review and revision of the tasks of government; if these tasks now demand a higher proportion of man-power than the nation can afford, it is the duty of the Government to say so and to re-orient policy accordingly. It is neither just nor prudent to attack the Civil Service for expansion or to demand a reduction in its size without initiating the policy and measures which will make some part of it redundant.

From whatever side this question of the organization of government is approached, the first need is some thought on fundamentals. There must be a clear conception of the purpose and functions of government, and of the rights and needs of the individual citizens which a democratic government exists to serve. We have had warnings enough in recent years that representative government can be just as tyrannical and intolerant as any feudal despotism, and that not only are the rights of individual citizens being infringed merely for administrative convenience, but also a diminished sense of ministerial responsibility has lowered standards of public life. Prof. Laski was not alone in arguing, as he did in his last lectures, that there has been no decline in the quality or status of the House of Commons or in its power to assert its will over that of the Government of the day in the face of some manifest injustice. There is nevertheless evidence that the stronger hold of the party system does in practice make the House of Commons less ready and less competent to act as the 'grand jury' of the nation, and with the elimination of the independent member something has been lost which Burke expounded so admirably to the electors of Bristol. The defence of freedom to-day may well require that a member should consider himself, as Burke did, not a member for Bristol but a member of Parliament; a representative owes his constituents, said Burke, in his speech on election, not his industry only but also his judgment.

The solution of the problem of making the best use of knowledge in government is perhaps less a matter of organization than Laski himself appreciated; in the long run, it is at least as much a matter of men and women, of personality and judgment, rather than formal relations. But the greater mobility and interchange which Laski suggested, for administrators as well as for workers in science and technology, and the freedom of communication, are important factors; they can contribute towards establishing the mutual confidence and understanding which are at least as important as any type of organization if the knowledge and skill of all three groups are to be linked fully and effectively in the service of the State.

FIFTY YEARS OF GENETICS

Genetics in the 20th Century

Essays on the Progress of Genetics during its First 50 Years. Edited for the Genetics Society of America by Prof. L. C. Dunn. Pp. xiii+634. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1951.) 37*s.* 6*d.* net.

THE Genetics Society of America is to be congratulated for having organized in September 1950 a meeting to celebrate the fiftieth anniversary of the re-discovery of Mendel's principles. This volume brings together twenty-six essays presented by distinguished American and European geneticists. They survey the developments and the outlook of genetics, its relations to biology in general and to specific fields in particular, and some of its appli-

cations to agriculture and medicine. In their gratifying variety of styles, subjects and objectives, none is irrelevant and one, by T. M. Sonneborn, may mark a turning point. In a short review it is impossible even to mention every one of these essays, let alone to do them justice.

R. B. Goldschmidt's opening address is a cheerful, almost enthusiastic, review of the impact of genetics on science; it comes as a surprise from the man who has been persistently ahead of the times with constructive criticism. It is to be hoped that this is only a natural effect of the elated atmosphere of the jubilee celebrations and not a reaction to the attacks now being waged against genetics. Three essays of historical character follow, one by H. Iltis on Mendel's life; one by Conway Zirkle on the knowledge of heredity before 1900; and one by W. E. Castle on his recollections of the first ten years of Mendelism in America. The last brings home the very important part played by mammalian genetics before the appearance of *Drosophila*. One episode is worth reporting: as late as 1909 Morgan was attacking the chromosome theory of inheritance; yet only three years later he and his unique team produced the theory of the gene.

The essay by H. J. Muller expounds the theme of the "gene as the basis of life", which he first outlined in 1926. The value of this idea has gained momentum in the past ten years during which the studies of heredity, embryology, immunology and biochemistry have come to share interests and techniques. It is an idea of great unifying value since it makes heredity, differentiation and evolution—life, as we know it, in one word—inevitable if one assumes a primitive structure capable of promoting the synthesis of more of its own kind, and of mutating, that is, of changing and promoting the synthesis of the changed kind. These are the properties rightly or wrongly attributed to the genes, the viruses and other 'self-duplicating' particles of to-day.

As the recent work on phage suggests, however, 'self-duplicating' particles, as we find them to-day, are meaningless without the highly organized synthetic mechanisms of the cell, of which mechanisms they are part and parcel and in which they act as specific primers. Sonneborn's essay—and one by B. Ephrussi—deal precisely with this central question of the interactions between genes, non-nuclear 'self-duplicating' structures, other cell systems structurally organized or not, and the environment. With unprecedented clarity these two essays state the nature of the problems for unifying genetics and development.

Another most valuable theoretical essay, on biometrical genetics, is by K. Mather. Genetics has learned to walk before trying to run: there is little doubt that its success has been due to the fact that the study of discontinuous variation has been dealt with first. Continuous variation, neglected since 1900, is just coming into its own again: its biological basis is now known to be the same as that of discontinuous variation; but Mendelian analysis cannot be applied to it. New techniques have to be invented. Mather's essay sets out lucidly the kind of problems involved and how they are beginning to be attacked. Perhaps as the statistical work of R. A. Fisher, Sewall Wright, J. B. S. Haldane and S. S. Chetverikov about 1930 reconciled Darwin and Mendel, this new biometry, in which Mather, J. L. Lush and M. Lerner lead, will ultimately reconcile Galton and Mendel.

Three essays on chemical aspects of genetics are by G. W. Beadle, by T. Caspersson and J. Schultz, and by A. E. Mirsky. An excellent summary of the genetics of antigens in man and animals is given by M. R. Irwin. J. Lederberg, who is responsible for one of the most spectacular recent advances in genetics, has contributed an essay on the genetics of bacteria. It is to be regretted that there are so many non-essential technicalities in it that the non-specialized reader may lose sight of the beauty of Lederberg's fundamental work.

Of the many other essays, I may mention a clear summary of the 'hybrid corn' developments by P. C. Mangelsdorf; a discussion on the evolution of cytogenetic mechanisms by M. White; one on population genetics by T. Dobzhansky; a short but stimulating one on human genetics by L. S. Penrose; and others by C. D. Darlington, A. H. Sturtevant, C. C. Little, J. L. Lush, A. Muntzing, L. H. Snyder and J. C. Walker, on subjects ranging from the meaning of Mendel's determinants to the genetics of resistance to diseases, from the genetics of cancer to animal and plant breeding.

In the closing essay by Julian Huxley, written in his lucid style, the part dealing with the novel mechanism of evolution emerging from the development of mind and of transmission by tradition is most stimulating.

Clearly this volume is one that no thoughtful biologist can ignore. G. Pontecorvo

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CHEMISTRY OF NUCLEAR PHYSICS

Radiochemical Studies

The Fission Products. Edited by Charles D. Coryell and Nathan Sugarman. (National Nuclear Energy Series, Manhattan Project Technical Section, Division 4, Plutonium Project Record, Vol. 9.) Book 1, Parts 1, 2, 3, 4, Papers 1 to 52. Pp. xxx+516. Book 2, Part 5, Papers 53 to 199. Pp. xvi+517–1315. Book 3, Parts 5 (contd.), 6, 7, 8, Papers 200 to 336. Pp. xix+1316–2086. (London: McGraw-Hill Publishing Co., Ltd., 1951.) 3 Books, 157*s*. 6*d*.

THE identification and determination of the elements resulting from nuclear reactions such as fission and spallation are clearly chemical problems, and since chemists usually take up physics more readily than physicists will pursue chemistry, this part of nuclear physics has been adopted by the chemists. This state of affairs is not so apparent in Great Britain as in the United States, because of the lack in the former country of sources of high-energy bombardment. The volumes reviewed here illustrate the type of work involved, and are the first collected account of a major undertaking in purely nuclear chemistry.

This work consists of a collection of papers, 336 in all, describing the war-time work on radio- and nuclear chemistry of various United States atomic energy establishments. They are principally concerned with the radioactive products of the slow-neutron fission of uranium-235 and plutonium-239 and their measurement. The papers are very heterogeneous both in quality and size, and, while this no doubt reflects the urgency of war-time work and the post-war dispersion of personnel, a stricter editing might have been employed. For example, three papers give three different methods of analysis for zirconium, yet

a fourth paper shows that two of them are unsatisfactory. Moreover, the information in some of the short papers is so small and lacking in detail that the data could very well have appeared only in tables of nuclear data in the appendixes. Notwithstanding these criticisms, however, these books are the only generally available collected source of information on their subject, and, while some papers are poor, many are of a high standard. Particularly worthy of praise are the editors' forewords (that to Part 1 is excellent) to the various sections (the volume is divided into eight parts) and the editors' footnotes, which point out published and unpublished work from 1946, when the papers end, to 1950 and greatly increase the value of the whole work.

Of the three books comprising the work, the first is undoubtedly the most valuable to those using the radiochemical technique, as it considers many aspects of β-particle measurement. Part 1, which is of a high standard throughout, contains some careful studies of a general radiochemical nature. Several papers are devoted to the effects of scattering on the conventional absorption methods of determining β-particle characteristics, and Paper 4 is a very useful though preliminary study of the effect of sample weight and the maximum energy of β-particles on self-scattering and self-absorption of the radiations emitted from samples. The magnitude of some of the effects is rather disturbing.

Part 2 is more chemical in outlook, and several papers are devoted to the behaviour of elements at very low concentrations, a subject which had previously been very little studied with elements other than those of the naturally radioactive series. The majority of the section, however, describes the first work (apart from one paper in 1934) on the chemical effects of β-decay and isomeric transition, a subject closely akin to the better-known Szilard–Chalmers reaction. Remote-control techniques are described in the third part. As the title implies, the papers refer to techniques for handling rather larger quantities of radioactive material than are generally encountered in the average laboratory using radiotracers. The design of laboratories for handling larger quantities of radioactive material is discussed in one paper, but unfortunately the more generally interesting topic of laboratories for microcurie amounts is mentioned only very briefly. Part 4 describes calculations and studies of unseparated fission products and is mainly technical in nature.

The biggest part of the book (and the most varied in quality) describes the investigations of the genetic relationships, half-lives, fission yields and energies of the radiation of more than a hundred fission products of uranium-235 and plutonium-239, on which are based the well-known fission-yield curves of these elements. While many of the results may be considered old, they are still authoritative. However, much remains to be repeated, using more refined techniques to give higher accuracy since, in general, fission yields by the radiochemical method as described are rarely better than ± 5 per cent. Also included are the only generally available data on the fission yields of plutonium-239, though this part is disappointing. The papers are short, repetitive and are confusing in that values given in the papers and some of the tables have been superseded by newer revised figures which are also included with the old in some of the tables but not in all. The revision is to some extent explained by a note added in proof in the concluding paper of the series; but the confusion remains although it is partially alleviated by the editors' footnotes. The chemical methods of separation of the elements described in the previous section are given in Part 6. The methods are, in many cases, based on standard analytical procedures adapted to the special conditions pertaining to fission product mixtures and are quite adequate for the purpose for which they were designed. Particularly interesting are those cases (for example, iodine and zirconium) where it was found difficult to ensure that the added carrier and the fission product existed in the same chemical states although the known states of the normal element were added or formed. It seems possible that this phenomenon is more general than is usually supposed.

The penultimate section describes some experiments on the inert-gas fission products, krypton and xenon, and investigations of their half-lives and daughter products by the methods of gas streaming along a charged wire. The technique is interesting but not of general use. The final section describes the miscellaneous investigations of a few radioisotopes which arose out of the earlier work but were not directly related to fission products. The books conclude with two appendixes containing the collected data on fission-product decay chains, fission yields and isotopes formed in thermal fission, and an author index and a good subject index. The books are very well produced, and there appear to be very few misprints. In conclusion, while many appraisals and criticisms can be made of individual papers, as would be expected of a collection of this size, the editors are to be particularly commended on their success in keeping the work up to date and on their forewords to the sections.

G. B. Cook

MANAGEMENT OF NATURAL POPULATIONS

Practice of Wildlife Conservation

By Dr. Leonard W. Wing. Pp. xi+412. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1951.) 44*s*. net.

No one should under-estimate the difficulty of studying, let alone of managing, a natural population, and the wildlife manager is in the unhappy position of being expected to produce the goods without understanding the process. He should therefore be a man who, among other things, must be willing to try out all kinds of ideas and yet be prepared for many of them to prove unworkable and be dropped without further loss of time. He must, in fact, be a man of imagination and have no illusions about the adequacy of existing knowledge. He may therefore find that the present book is neither bold enough in its outlook (for example, over the deer problem) nor sufficiently critical of the past. These deficiencies from the practical point of view have probably resulted from an over-simplification of the theory.

Two of the early chapters in this book fill certain gaps in the student's general biological knowledge, though not all the facts seem relevant to what follows. Later chapters describe the natural history of the game, fish and fur-bearing species and how to estimate and conserve their numbers, but do not show how well the methods work. Population theories of the past quarter of a century receive less

than their fair share of attention. It is proposed that "biotic potential" be corrected by an "internal adjustment factor" to allow for changes in reproductive-rates as numbers increase; this figure minus "environmental resistance" is stated to equal the population (apparently not its rate of change).

It can certainly be argued that these and similar abstract terms are useful in describing population processes that we cannot yet understand. On the other hand, there is a danger that the label may be confused with what it describes, and lead to an inflexibility of thought not warranted by the evidence. For example, the following views are presented: an environment has a certain carrying capacity such that animals in excess of it will be lost; the carrying capacity may be increased by improving the environment up to a saturation point which is "a function of the animal psychological pattern, rather than of the land"; predators remove individuals in excess of the carrying capacity but otherwise prey chiefly on the weaker members; predators are effective in controlling certain rodents (but not the grey and fox squirrels, which are game animals).

Now these are controversial matters which should be treated with extreme caution. The present book is unsatisfactory in this respect, particularly since authorities are not quoted in the text. It is true that a policy based on these hypotheses has the attraction that it may lessen the slaughter of predators and encourage 'common-sense' procedures such as providing food in winter and planting cover. But the sad fate of other common-sense ideas under scientific scrutiny gives little confidence that the problems of conservation can be solved without a more fundamental approach than any that is here suggested.

Dennis Chitty

CALCULUS OF EXTERIOR FORMS

Forme Differenziali e loro Integrali

By Prof. Beniamino Segre. Vol. 1. Pp. 520. (Rome: Istituto Nazionale di Alta Matematica, 1951.) 3900 lire.

THE past twenty years have witnessed the final stages of what is perhaps the most remarkable synthesis in pure mathematics; during this period, a concept of multiplication, introduced by Grassmann and Hamilton more than a century ago, and now familiar to all in the algebra of vector products, has gradually penetrated analysis and geometry until what began as a convenient abridged notation and continued as a unifying force has ended in the creation of highly important branches of mathematics which include many classical theories as mere special cases.

In this field, known as the calculus of exterior forms, at least eight chief disciplines may be discerned, of which seven have recently converged to form the last. To begin with, there is the non-commutative algebra of Grassmann, with its interesting applications to geometry. Then there is the theory of systems of differential equations, including Pfaff's problem, transformation groups and integral invariants. Allied to this is Volterra's concept of functional, with the accompanying theory of integral equations and applications to Dirichlet's problem for any number of variables. The fourth group of subjects deals with generalizations to many complex variables of the classical results due to Cauchy and Riemann. The next three groups are predominantly geometrical in inspiration. First, from Abel's theorem for an algebraic curve stem generalizations to integrals taken over surfaces and then algebraic manifolds of any dimension. Linked with this subject is Riemann's pioneer work on the topology of surfaces, later extended by Poincaré to general manifolds; and then, flowing from a quite different source, comes the stream of differential geometry, initiated by Gauss, generalized by Riemann, and reduced to a technique by the invention of the tensor calculus.

Within this generation it has been perceived, notably by E. Cartan, that the Grassmann algebra, applied to differential forms, could have a remarkable unifying effect upon the varied subjects described above. This discovery has led to the final synthesis: the theory of harmonic integrals, due to Hodge, deriving from de Rham, in which all the preceding material finds an essential place. (Only recently has it been noticed that these integrals are to be found in early work of Volterra.)

Until now it has been impossible for the non-specialist to acquire an adequate notion of this vast theory, some of which has never before appeared in book form, and most of which has not hitherto been expounded anywhere in the compact symbolism of the new calculus. The gap has at last been partly filled by the present lithographed work, which is based on lectures recently given in Rome. This, the first of two volumes, consists of four chapters, each sub-divided into numerous sections. The treatise opens with a short introduction which explains quite simply the nature and scope of the investigation. In the first chapter the Grassmann algebra is developed and applied to various problems of geometry. In Chapter 2 these concepts are brought to bear on the differential and integral calculus, the central point being the generalization of Stokes's theorem to any number of variables. The author then passes to the subject of differential equations, including infinitesimal transformations and integral invariants. Chapter 4 begins with a study of complex Euclidean space and the associated theory of complex variables, and thence proceeds to functionals and the general Dirichlet problem.

This brief summary, which mentions only the leading topics in the book, may well cause one to wonder how they could all be brought within the present compass. It is therefore the more striking that the treatment is not simply adequate but wholly comprehensive throughout; at no point does the author assume any special knowledge on the reader's part: on the contrary, he actually includes accounts of extraneous theories so as to render his exposition autonomous. Much of the latter is either original—for example, certain sections of Chapter 3, and the treatment of functionals—or, as in the account of functions of many complex variables, is derived from the work of Prof. Segre and his pupils.

At the end of each chapter there is a bibliographical note, composed of comments and references, which evinces a rare erudition. The work displays on every page the elegance and expository skill characteristic of the author: the wide territory is not merely surveyed, but surveyed from a single point of view. In fact, Prof. Segre's grasp of his subject is such that at any moment he can (and often does) call up any other of his themes so as to place it in relation to the matter in hand. This is a very important addition to the literature.

L. Roth

NEW MATERIALS IN ENGINEERING*

By Dr. T. E. ALLIBONE, F.R.S.

Research Laboratory, Associated Electrical Industries, Ltd., Aldermaston Court, Aldermaston, Berks

ONE of the most remarkable developments of the past decade has been the growth of the industry based on synthetic polymers. Although some of these have been known in the laboratory for a long time, their large-scale development has been expedited by the War. Thus polythene, first made in 1933, was beginning to be used as a dielectric in cables in 1939; but, on account of its low dielectric loss, it quickly came into use in ultra-high-frequency circuits used in great number thereafter, and to-day it has revolutionized communication engineering, and its production has increased by a thousand times in ten years. Production of synthetic rubbers has been similarly expanded: some of these materials are more resistant to chemical attack than is natural rubber, some are almost impermeable to air and moisture and are used for sealing insulation, and some are very tough; these are used extensively in place of rubber to insulate electrical conductors. Co-polymerization of synthetic resins *in situ* eliminates voids in insulation, as there are no solvents to be evaporated and the co-polymer occupies almost the same volume as the constituent polymers. Some of the silicone polymers are water-repellent and may usefully be applied as a surface coating to insulation. Synthetic adhesives having good insulating and mechanical properties are being used experimentally to fasten porcelain to metal for a variety of uses and, mixed with zircon, provide strong insulation of high electric strength. It is interesting to reflect that the volume of plastics produced to-day exceeds the volume of all the non-ferrous metals produced.

Barium titanate and a family of related substances have dielectric constants many times larger than mica, due to a small misfit of the crystalline lattice. They can be used to make very compact condensers, and the same physical feature of the lattice is responsible for their having strong piezo-electric properties. The high dielectric constant disappears at elevated temperature, as does high magnetic permeability, and, because of the similarity which exists in a number of ways between these dielectrics and ferro-magnetic materials, they have become known as 'ferro-electrics'. They are of special interest on account of their stable chemical composition and high electric strength, and are generally expected to find many applications in electrical engineering.

Semi-conducting elements such as silicon are very old; but the production of these in pure form, or containing controlled traces of impurities, is very new and has resulted in a complete re-assessment of the importance of semi-conductors. Silicon/tungsten rectifiers were extensively used in the War in radio-frequency circuits; the more recent interest in germanium as a rectifier stems from the high voltage (about 100 V.) that can be applied in the reverse or non-conducting direction. Within the past three years the three-electrode germanium 'valve' has been developed—the 'transistor'—which may replace thermionic valves in many circuits and supplement them in many others, especially when more research has been done to eliminate some of the disadvantages possessed by this new invention. In its simplest form the transistor consists of two closely spaced tungsten wire 'cats-whiskers' in contact with a germanium crystal; flow of current in one tungsten–germanium contact modifies the current/voltage characteristic of the other contact. In later forms two or three distinct types of germanium have been placed—or grown—in contact with one another, the contact area being far greater than between wire and germanium, and this rectifying junction may even become a power rectifier. These new devices may only be the beginning of a vast development based on a better understanding of the electronic conduction process in materials which are almost insulators. Thus the mixture of two metal oxides, each a good insulator, can have quite low resistance due to the movement of valency electrons from one to another metal ion. Mixtures of such oxides have been applied as semi-conducting glazes to porcelain insulators to improve the potential distribution across them. Some of the mixtures have a very large negative temperature coefficient, and as 'thermistors' they have been used for detecting radiant energy, and as temperature indicators. The mixed oxides of iron have received recent attention, and permeabilities of 1,500 have been reported: they find extensive use in high-frequency circuits where their relatively high resistivity reduces hysteresis loss to low values. New developments of photo-conducting crystals provide detectors of X-rays and infra-red rays.

Magnetic materials are now profiting from the extensive basic research of the past twenty years, the cost of which may be fully repaid by reduction in hysteresis loss in electrical machines—alternators, motors and transformers. Silicon–iron alloy is now used with very little carbon or sulphur impurity. After rolling to sheet form, the alloy is annealed in hydrogen and recrystallization occurs with the [100] crystal axis in the direction of rolling; the lower the impurity the more perfect the crystalline alignment and growth. This axis is the axis of easy magnetization; along it the flux rises at low magnetization until saturation occurs quite suddenly, and in this direction of magnetization hysteresis loss is a minimum. Sheet steel produced commercially in huge quantities has a hysteresis loss only half of what was considered low a few years ago.

The very sudden transition from a state of being partially magnetized to one of magnetic saturation of these modern post-war iron alloys, particularly the nickel–iron alloys, opens up a wide new field of application of iron cores as 'switches' without moving contacts.

The electrical engineer is dependent on new developments in metallurgy. He wants higher temperatures for turbines, greater resistance to corrosion of metals, metals which do not absorb neutrons but have the right mechanical properties for use in atomic piles to operate at temperatures high enough for good efficiency, metals with good cutting properties, and metals showing low friction and small wear for use in bearings. Sintering of metal and non-metallic powder mixtures in the electric induction furnace has provided the hardest metals, the impreg-

* Substance of a Friday Evening Discourse at the Royal Institution delivered on November 16.

nation of sintered metal with a lubricant such as the modern plastic tetrafluorethylene has furnished a bearing surface of very low friction. and attempts have been made to improve on the best steels for turbine blades by sintering mixtures of metals with carbides or oxides or borides, but this development is still in its infancy.

The electric arc furnace described more than a hundred years ago is at last coming into its own for melting metals like titanium and zirconium in argon to avoid oxidation, and both metals are being produced in bulk.

AUTOMATIC COUNTING OF MICROSCOPIC PARTICLES

THE problem of measuring the number and size of fine particles is ubiquitous; it arises in fields as diverse as powder metallurgy, chocolate-making and the control of atmospheric pollution. Frequently, the only practicable method is by visual counting of the particles under the microscope; but this is tedious and subject to personal bias. The possibility of making a machine to replace the human observer has recently received widespread attention and, indeed, several are already under development. Two discussions were arranged* by the National Coal Board between those known to be working on the problem, attended by representatives from fifteen universities and research establishments. The chair was taken by Dr. J. Bronowski, director of the National Coal Board Central Research Establishment: Dr. C. N. Davies deputized for part of the proceedings.

Outline of Problem

The problem considered is, briefly, to count and measure the size of small objects scattered at random over a given area, for example, blood corpuscles in a hæmocytometer cell, or airborne dust particles deposited on a glass cover slip. It will be seen that this is quite different from the simple problem of counting objects which can be passed through a detecting device one at a time in an orderly row, as peas before an 'electric eye'. Instead, the specimen must be scanned by a small element of area which moves progressively over the whole field or a representative part of it, so that only a tiny portion is seen at any instant, as in the scanning of a television picture. Now if this scanning area is large compared with a particle, more than one particle may be within it at the same instant and be measured as one. It will also happen that some particles near the edge of the scan line will fall only partly within it and may do so again on the next line. In each case, both the number and the size of the particles will be indicated incorrectly unless correction for these effects is made. The percentage of partial interceptions will be reduced if we increase the width of the scan line, but this will increase the probability of encountering more than one particle at a time, so that a compromise between the two must be made. On the other hand, if we make the scanning spot very small so that it draws thin lines across the specimen, only one particle will be intercepted at a time, but the number of intercepts will not represent the number of particles, nor will the lengths of the intercepts represent the particle diameters, because particles of different sizes will give different numbers of intercepts and a given particle will give intercepts of various lengths.

* On June 12, 1951, and February 8, 1952.

Principles of Operation

Many ingenious ways of overcoming these difficulties were described or proposed in the course of the discussions. Details of individual contributions will be given later, but the following general principles may be noted:

(*a*) '*Double Scan*' *Method.* In 'wide scan' methods, the number of particles cutting the edges of the scan track may be estimated and allowed for by comparing the counts obtained from two scans with tracks of different widths. These two measurements may be made independently by scanning the specimen twice with apertures of different widths, or simultaneously by two such scanning apertures placed side by side.

The following methods relate to a narrow scan line:

(*b*) *Intercept Length Method.* The numbers and lengths of the intercepts of the scanning lines across the particles are recorded. From this information the aggregate area and perimeter of the particles are readily obtained. The number and size distribution of the particles can be calculated with some difficulty if their shape is known. The system may be compared with the well-known micrometric integrating stage method for measuring the mineral constituents of rock sections.

(*c*) *Guard Spot Method.* Two scanning spots are provided, separated transversely to the direction of motion, one of which controls the counting of the other. The absence of the control signal indicates that the lower (or upper) edge of a scanned particle has been reached and the particle is then recorded. Its size is not given, although a lower limit to the detection-level may be set. The size distribution may be obtained by repeating the measurements at each of a series of such limits.

(*d*) '*Memory*' *or* '*Sequential Signal*' *Method.* Repeat signals from the same particle in successive scan lines are characterized by their occurrence in a regular sequence at corresponding times or positions. Such sequences of signals are grouped and counted as single particles at the end of the sequence, the size of the particles being obtained from the number of signals in the sequence or from the intercept lengths.

Apparatus

The apparatus consists of: (1) a scanning device to produce electric pulses related to the size and spatial distribution of the particles, and (2) a means of analysing and recording the pulses to give a measure of the scanned particles. The scanning is usually effected by a light beam and photo-cell arrangement. Either the specimen itself may be moved mechanically in relation to a fixed optical system, or the light beam may be moved. The former method is more applicable to 'wide scan' techniques. A 'narrow scan' is conveniently obtained from a cathode ray tube as the light source, by television techniques. Another method is to use a television camera in which the image of the specimen is scanned by an electron beam.

The problem is essentially the same whatever the size of the particles, and in a general-purpose instru-

ment it should be possible to vary the working range, for example, by a change of optical magnification. When microscopic objects are to be examined, the usual optical problem of getting enough light through the system arises. Thus, the scan spot may be as small as 1 μ diameter, so that if a cathode ray tube with a 1-mm. spot be used as the source, less than 1/1,000,000 of the light from this can be concentrated through the specimen. The detector unit must therefore be a photo-multiplier cell in most cases.

Individual contributions to the discussions are summarized below.

Large Scan Spot

Mr. H. S. Wolff (Medical Research Council, Pneumoconiosis Research Unit), Dr. R. G. Macfarlane and Dr. J. C. F. Poole (Radcliffe Infirmary, Oxford); Mr. E. H. Cooke-Yarborough (Atomic Energy Research Establishment); and Mr. E. W. Meyer (C. F. Casella and Co., Ltd.) described 'wide scan' systems with mechanical scanning, designed particularly for counting blood cells.

In each case the specimen was moved so that its image traversed a fixed aperture in the image plane and the light passing through the aperture was measured by a photo-multiplier cell. Mr. Wolff used a single aperture in the form of a slit, and the specimen was scanned twice with the length of the slit perpendicular and parallel respectively to the direction of motion. This gave a correction for particles partially intercepted at the edges of the scan[1,2]. The apparatus had been in satisfactory operation for eighteen months. He suggested that with a similar system the duration of the pulses could be used to give a measure of particle size. Mr. Cooke-Yarborough's apparatus resembled the above in its main features, but corrected for edge effects by the use of two slits in the second count, each of half the length of the original. Mr. Meyer corrected for partial interceptions by the simultaneous use of two adjacent apertures, each with its own detecting system, in a kind of 'guard spot' arrangement. Particles crossing the lower boundary of the main scan track were detected by the second photo-multiplier operating an anti-coincidence circuit[3]. At a later stage, the amplitudes of the photo-electric signals would be used to give a measure of particle size.

Mr. D. A. Bell (University of Birmingham) suggested the use of a scanning system with a large slit or chequer-board aperture. The total signal represents the resultant of contributions from numerous particles, and a frequency analysis of the signal spectrum can be used to estimate the size distribution of the particles[4].

The remaining contributions relate to 'narrow scan' systems.

Intercept Lengths

Mr. E. R. Hoare (National Institute of Agricultural Engineering) described apparatus for evaluating spray droplet stains on paper by the intercept length method[5]. The stains were relatively large, 0·5 mm. to 8 mm. diameter, and the papers were scanned on a standard facsimile picture-scanning machine. Two methods of pulse-length discrimination had been used: (*a*) by comparison of the pulses with the natural periods of trigger circuits set by the leading edges of the pulses, and (*b*) by conversion of pulse lengths to amplitudes followed by analysis in an amplitude discriminating circuit. Test patterns of black circles on a white ground were used for checking instrument performance, and excellent agreement with predicted values had been obtained. It was difficult to determine the number of particles by the intercept-length method. A shape factor had to be assumed, and it was necessary to measure intercept lengths down to a fifth of the diameter of the smallest particles evaluated. Alternatively, when dealing with a constant shape of particle, intercept-length distributions themselves gave a measure of the particles in a language that was soon understood even though it was difficult to translate into common terms.

Mr. P. G. W. Hawksley (British Coal Utilisation Research Association) had obtained theoretically the relation between the size distribution of the particle images and that of the intercept lengths for both circular and elliptical images. Measurements of the number and size distribution of the intercepts and of the circularity of the particles enabled the concentration, average size and variance of the particles to be deduced. An apparatus was under construction[6].

Mr. J. G. Dawes (Safety in Mines Research Establishment) had worked out the interpretation of an intercept-length distribution in terms of the concentration and frequency function of the particles in two special cases: (1) for the simple case of an element of infinitesimal width scanning circular images, and (2) for a finite track width and given length defining gate-level, it being assumed that particles of given size (projected area) but of different shapes and orientation give a rectangular distribution of intercept length.

These two theories had been tested using photomicrographs of coal dust. In neither case did the results differ greatly from those obtained by 'normal' counting.

'Guard Spot' Methods

Mr. Frank Roberts (Anatomy Department, University College, London) gave an account of the flying-spot microscope he had developed in collaboration with Prof. J. Z. Young[7,8]. This was a device for displaying a microscopic object on a cathode-ray oscilloscope (C.R.O.). The scan source was a film-scanning tube, the moving spot of light from which was projected at reduced size through the specimen under the microscope. The transmitted light was picked up on a photo-multiplier cell and the amplified signal applied to a C.R.O. scanning in synchronism with the source. He thought that in such a scanning microscope there was no theoretical limit to the resolving power in the direction of scan; detail smaller than the Airy disk should be detectable. Pulse analysing and counting equipment for assessing particulate specimens was now being developed. The display C.R.O. would provide a means of monitoring the counted signals.

Mr. Roberts proposed to use a 'guard spot' method of counting in which the two scanning spots were formed by splitting the light beam with a doubly refracting crystal[9,10]. The two spots were thus plane-polarized in mutually perpendicular directions and were directed into separate photo-multipliers by means of a polarizing prism. Pulses from the two channels were combined to give a guard pulse lying, in time, within the main pulse the counting of which it controlled, so that it would be possible to count closely-grouped particles. A method of selectively counting particles of predetermined shape had also been devised, depending on matching the signals

from the scanner, when displayed on a cathode ray tube, with a mask placed in front of the tube[11].

Mr. Roberts gave a demonstration of his apparatus at the end of the second meeting.

Mr. E. H. Cooke-Yarborough proposed a 'guard spot' method in which, during each 'major' line scan, the scanning beam would execute a rapid transverse 'minor' line scan of small amplitude. At the corresponding end of each minor line scan there would be a 'guard zone', and a particle would be counted subject to the condition that it produced signals in two or more consecutive minor line scans without producing signals in two or more consecutive guard zones[12]. This would give a well-defined lower size limit. Mr. Cooke-Yarborough stressed the desirability of using simple circuits, and suggested that size analyses might be obtained by repeating the scan a number of times at different lower limits of discrimination.

Dr. H. A. Dell (Mullard Electronic Research Laboratory) described a 'guard spot' method in which the scanning spot during its sweep was switched at a high frequency between two transversely disposed positions, one of which was the 'guard' position. Simultaneous switching of the photoelectric detecting circuit enabled the signals from the two spot positions to be distinguished. The guard position was in advance of the main position to ensure that the signal was received in time to control the main pulse[13]. It was considered that experience with such a relatively simple system would form a valuable preliminary to the development of the more elaborate 'memory' devices required to give a complete size analysis (see following contributions).

'Memory' Systems

Dr. D. W. Gillings (National Coal Board) put forward a 'memory' system[14], which would give directly the number and size distribution of particles. The equipment would have a number of memory channels, and the signal arising from the first interception of the scanning beam by a given particle would be directed into a vacant channel. The same channel would be switched momentarily into circuit again one scan period later and so would receive any signal from the same particle on the next scan line. This process would continue until there was a break in the sequence of signals, when the particle would be recorded in the size group defined by the number of signals received, and the channel would be released for further counts.

Dr. C. F. Bareford and Dr. H. A. Dell (Mullard Electronic Research Laboratory) proposed a variation of this method, which included the use of scanning potential-levels instead of timing circuits to control the switching of occupied channels, and sequential instead of ring memory channel selection[15].

Mr. W. H. Walton and Mr. D. G. A. Thomas (National Coal Board) suggested the use of a magnetic drum memory to identify intercepts in successive scanning lines from the same particles [6]. One form of the device was for counting only. In a second form, for counting and sizing, signals from successive interceptions of the same particles were superimposed on the drum, giving a record, on completion of the scanning of that particle, the overall length of which was a measure of the projected diameter of the particle. This cumulative record was 'gated' by the presence or absence of new signals and, when there were no further signals, was passed to pulse-length discriminating and counting circuits. The record was then erased from the drum. Other applications of the drum recorder were outlined.

Dr. V. Timbrell (Pneumoconiosis Research Unit) made a novel suggestion, that it might be arranged for the scanning electron beam of an orthicon tube to be 'pulled' to the charged image of a particle and held there until the image was removed. The normal scan would then be resumed until the next image was encountered. Signals would thus be produced proportional to the areas of the particles, and the removal of the images would prevent repeat counting.

The foregoing account will have revealed the widespread effort that is now being made to meet the need for an apparatus to relieve human observers of the labour of counting and sizing microscopic particles, and to improve the consistency of results. The subject presents a fascinating variety of technical problems the solution of which has been made possible by recent advances in technique in other fields. We can confidently expect that automatic counting apparatus to suit many requirements will become available during the next few years. A close interest in these developments is being shown by national organizations such as the Medical Research Council, the Department of Scientific and Industrial Research and the National Research Development Corporation. The National Coal Board is constructing apparatus for its own needs in collaboration with the Mullard Company.

I am indebted to the contributors to the discussions for permission to disclose so much novel material.

W. H. Walton

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HIGH-ENERGY NUCLEAR PHYSICS AT HARWELL

By Dr. T. G. Pickavance and Dr. J. M. Cassels
Atomic Energy Research Establishment, Harwell, Nr. Didcot, Berks

THE 110-in. frequency-modulated cyclotron at the Atomic Energy Research Establishment, Harwell, has been used since December 1949 as a source of high-energy protons and neutrons in a programme of nuclear research. The cyclotron was briefly described[1] soon after its completion, and the results of much of the research work have now been published. An invitation has recently been given to universities in Great Britain to make use of the cyclotron, so that the time is opportune for a

description of the facilities available and the lines along which research is at present directed.

Some of the results of the work to be described were used by Sir John Cockcroft[2] to illustrate his recent Friday Evening Discourse at the Royal Institution on the present situation of high-energy physics.

Output of the Cyclotron

The maximum proton energy is 175 MeV. at an orbit radius of 50·4 in., and the mean internal current is normally 1·3 microamp. Under rather special operating conditions, 2·0 microamp. can be reached. The pulse duration is about 500 microsec., and the repetition-rate is usually 100 c./s. An external proton beam is obtained by scattering from a uranium target, $\frac{1}{4}$ in. thick, at 49·8 in. radius. Protons scattered outwards through about 4° in a horizontal plane pass through a magnetic shield and emerge from the machine through an evacuated tube about 40 ft. in length. The total extracted beam current is about 3×10^{-10} amp., and the flux of protons available 40 ft. from the cyclotron, behind a shielding wall 8 ft. in thickness, is now 2×10^5 protons cm.$^{-2}$ sec.$^{-1}$. Focusing devices, now being built, should increase this flux by about a factor of 50. However, the present intensity has been found entirely adequate for experiments on proton–proton and proton–deuteron scattering. The pulse duration of the external proton beam is about 150 microsec., and its energy is 147 ± 1 MeV.; the reasonably small spread of energy is attributable to the dispersive effect of the fringing field of the cyclotron magnet.

The energy-spread of the internal beam intercepted by a target is much broader, however. A part of the spread is caused by radial oscillations of the protons in their orbits, and measurements of this effect have been made by J. M. Dickson, who has used again a method originally developed at Harvard. Protons, scattered from the beam by a thin target, were allowed to travel through 180° of arc in the magnet gap before striking a row of carbon plates held below the median plane. The apparatus is then effectively a magnetic spectrograph, and measurements of the radioactivity induced in the carbon can be used to derive the energy-distribution of the protons striking the target. The width of the spectrum, at half height, is about 10 MeV., and it has been found to increase linearly with dee voltage when other operating conditions are kept constant. On extrapolation, the line does not pass through zero spread at zero dee voltage, and so far no other repeatable correlation with operating conditions has been found.

There is an additional spread of energy caused by multiple traversal of the targets by the internal beam. This has been investigated by J. M. Cassels, J. M. Dickson and J. Howlett[3]. Their theoretical treatment follows the motion of a proton under the combined influence of multiple Coulomb-scattering in the target and focusing by the magnetic field. They have checked the theory by irradiating carbon targets of various thicknesses at various radii in the cyclotron and measuring the yield of carbon-11 so produced. Agreement is good, and it is now possible to determine the number of traversals (and hence the effective beam current and the spread of energy) for any set of operating conditions. For thin targets the effective beam current may be as high as 30 microamp., that is, the protons may pass through the target fifteen times on an average. The number of traversals may be limited by reducing the effective aperture of the dee.

The neutron beams produced by the cyclotron can be collimated by any one of eight holes through a shielding wall 6 ft. in thickness. Immediately behind the shielding wall the flux of neutrons with energies greater than 60 MeV. is 2×10^5 cm.$^{-2}$ sec.$^{-1}$ when a beryllium target is bombarded at the full radius.

The Research Programme

The maximum proton energy of 175 MeV. is scarcely above the threshold for the artificial production of π-mesons, and consequently the yield of these particles is very small. The background of neutrons and protons is as high as that produced by larger cyclotrons, and so it has not been possible to make any useful contribution to meson work. Since the 350-MeV. electron synchrotron at Glasgow and the 400-MeV. cyclotron at Liverpool will produce good yields of mesons, it was clear that the work of the Harwell cyclotron should be concentrated on fundamental scattering problems, and studies of nuclear reactions at high energies. This work can be done with advantage, since the cyclotron has an exceptionally high beam current.

About 15 per cent of the running time has always been left free for work outside the main programme. Part of this has been used by Dr. F. D. S. Butement for radiochemical work, and part by Prof. E. W. Titterton for studies of star production by neutrons and protons in nuclear emulsions.

Neutron Energy Spectrum

A knowledge of the production cross-sections and the energy spectra of neutrons produced by proton bombardment of various targets is required, not only as a basis for further work with neutrons but also because the mechanism of neutron production is of interest in itself. The yields and energy distributions of neutrons produced in the forward direction, by 171-MeV. protons, have been determined by J. M. Cassels, T. C. Randle, T. G. Pickavance and A. E. Taylor[4], who carried out experiments with targets of beryllium, carbon, aluminium and uranium, using a method which enabled neutrons in a predetermined narrow energy-band to be investigated.

The most interesting feature is that the spectrum always shows a pronounced peak at a high energy; in the case of beryllium this peak is at an energy not more than 20 MeV. below the primary proton energy. This fact shows that the incoming proton interacts with individual nucleons in the target nucleus, rather than with the nucleus as a whole. If a compound nucleus were formed, the average energy of emitted neutrons would be quite low. A detailed theoretical study of neutron production by protons has been made by F. Mandl and T. H. R. Skyrme[5].

Similar experimental results have been obtained for beryllium at Harvard, where the protons had a lower energy. At Berkeley, however, the peak of the spectrum has been reported to be 70 MeV. below the proton energy. Their different result may perhaps be attributed to differences in instrumental conditions, such as the energy-spread of the proton beam, the number of traversals of the target, and the width which the apparatus used to measure the spectrum can resolve.

Neutron Total Cross-sections

The presence of a peak in the neutron spectrum so near the upper limit set by the proton energy has an important consequence for the neutron work. In many experiments it is possible to use a recoil proton 'telescope', in conjunction with a hydrogenous scatterer, as a neutron detector. This apparatus was first developed for high-energy physics at Berkeley; it consists of a number of counters operated in coincidence and separated by absorbers. The threshold energy is easily controlled by adjusting the absorber thickness, and therefore attention can be restricted to as narrow a band of neutron energies as desired, since an upper limit to the energy of the neutrons is set by the radius of the target inside the cyclotron. The high-energy peak enables good counting-rates to be sustained even when the band is made narrow. There is no suitable high-energy peak in the spectrum of neutrons produced by deuteron bombardment.

So far this technique has been used only at Harwell. In other laboratories neutrons of widely differing energies were accepted, and the effective energy had to be calculated from the energy-dependence of the detector and the energy-spectrum of the neutrons, two factors which are often subject to uncertainty. This fact has led to fairly general scepticism about the value of total cross-section measurements with high energy neutrons. For example, Chamberlain, Segrè and Wiegand, reviewing Berkeley experiments in a recent paper[4], make the following statement: ". . . the angular distributions are thought to be better known than the total [neutron] cross-sections. For instance, at 90 MeV. the angular distribution is probably known to about 5% while the total cross-section is known only to 15%. (The uncertainties in the total cross-sections stem not from the cross-section measurements themselves, but from the uncertainties in the effective energies at which the observed cross-sections are considered to apply.)" This criticism certainly cannot be levelled at the Harwell neutron experiments.

The technique just outlined is particularly well suited to the determination of total cross-sections, where the experiments consist of 'good-geometry' measurements of the attenuation produced when samples of various elements are inserted into a neutron beam. The effective neutron energy tends to increase as the beam passes through the attenuator, since in this energy region the cross-section decreases with increasing energy. If the upper and lower energy limits of the experiment are sufficiently close together, this effect cannot influence the experimental results.

A series of total cross-section experiments has been made by A. E. Taylor, T. G. Pickavance, J. M. Cassels and T. C. Randle[7]. The total neutron–proton cross-section was determined at effective neutron energies of 156 ± 3, $97 \pm 1{\cdot}5$, $64{\cdot}5 \pm 1{\cdot}6$ and 39 ± 1 MeV. The lower energies were obtained by setting the target at progressively smaller radii in the cyclotron, suitable adjustments being made to the thickness of carbon absorbers[8] between the counters.

The theoretical values of the total neutron–proton cross-section, derived by Christian and Hart at Berkeley and by others, have been made as low as possible by reducing so far as possible the interaction in odd states of angular momentum; but they are still too high to be compatible with the experimental results at 95 and 156 MeV. The difference at 156 MeV. is especially marked. At 39 and 95 MeV. the Harwell results are in agreement with the latest ones from Berkeley but not with the earlier ones; the result at 156 MeV. is appreciably lower than the corresponding one from Berkeley.

Total cross-sections of nine other elements have also been determined, at a neutron energy of 156 ± 3 MeV. Four of these elements have been investigated at Berkeley at energies where the results may be compared, and for three of them (carbon, aluminium and lead) the Berkeley and Harwell results differ by about five times the larger of the two stated errors. Thus the experimental situation so far as the elements in general are concerned is less satisfactory than in the particular case of hydrogen, and the Harwell measurements are therefore being extended to other energies.

Differential Neutron–Proton Cross-section

Following upon the determination of the neutron–proton total cross-section, the angular distribution of neutron–proton scattering has been studied by A. E. Taylor, E. Wood and T. C. Randle[9]. The same technique was used for measuring the number of recoil protons as a function of the angle of ejection from the scatterer. The absorbers between the counters were adjusted at each angular setting so that the effective neutron energy was always 156 ± 3 MeV. The ratio of the differential cross-section at 180° to that at 90° (in centre of mass space) is 5·0 : 1, and there is a slight asymmetry about 90°. The shape of the distribution, which seems to indicate the presence of some interaction from tensor forces in odd states, is in general agreement with Berkeley results at lower and higher energies.

Angular Distribution of the Neutrons

The angular distribution of neutrons produced by 170-MeV. proton bombardment of beryllium has been measured by M. Snowden[10]. Coincidence counters with absorbers were used again, and distributions were measured with several values of the threshold energy of detection. The results show a narrower distribution for a higher threshold energy, and this is further evidence of interaction with individual nucleons in the target nucleus.

Mechanism of High-Energy Nuclear Reactions

After a bombarding proton has passed through the nucleus, knocking out one or more high-energy particles, the residual nucleus is left excited. In a heavy nucleus the energy of excitation becomes distributed over all the nucleons which remain; it is dissipated comparatively slowly by the evaporation of low-energy neutrons and protons. The evaporation neutrons have been investigated by D. M. Skyrme and W. S. C. Williams[11], who exposed nuclear emulsions to the neutrons leaving a tungsten target in the backward direction. The shape of the energy spectrum is consistent with evaporation theory and has a peak just above 1 MeV. The absolute yield was such that an average of four neutrons must have been evaporated for each inelastic collision between a 170-MeV. proton and a tungsten nucleus. Results obtained with a carbon target show that in light

nuclei the excitation energy is not completely redistributed during the intermediate stage of the reaction.

Experiments with Protons

An experiment on proton–proton scattering at 146 ± 1 MeV. has been made by J. M. Cassels, G. H. Stafford and T. G. Pickavance[12], using the external proton beam. At first the $^{12}C(p,pn)^{11}C$ reaction was used to measure the primary proton flux; but recently the experiment has been repeated[13] using a photographic plate method for this purpose. The angular distribution of scattering was found to be isotropic, in agreement with the results of all other high-energy proton–proton experiments; but the value of the differential cross section (4·86 ± 0·25 millibarns-steradian^{-1}) is in sharp disagreement with a Berkeley result (3·72 ± 0·29 millibarns-steradian^{-1} at [illegible]).

Similar experiments have been performed at Harvard and at Rochester, at lower and higher energies respectively. The latest Rochester result is also about 30 per cent higher than that obtained at Berkeley, but the absolute accuracy of the Harvard results is not yet good enough to give definite support to either the higher or the lower value for the cross-section. The Berkeley experiments indicate that the cross-section is substantially constant from 120 MeV. to 340 MeV., and this issue does not seem to be in question. The conflict, which has not yet been resolved, is in the absolute value of the cross-section.

Attempts have been made at Berkeley with moderate success to interpret the proton–proton results theoretically. Christian and Noyes used an interaction incorporating short-range tensor forces, whereas Jastrow introduced a strong repulsive force at short distances.

A comparison of proton–deuteron and neutron–deuteron scattering at the same energy would show whether the neutron–neutron and proton–proton interactions are the same. If they are, then the only differences should be in the very forward direction, where Coulomb effects become important. Subtraction of the neutron–proton total cross-section from the neutron–deuteron total cross-section to give the neutron–neutron total cross section has been proposed, and the Harwell results show that the result of this operation is definitely lower than the proton–proton total cross-section. The criticism can be made, however, that interference effects might be responsible; this difficulty would not arise in a comparison of corresponding proton–deuteron and neutron–deuteron effects. As a first step, experiments on the elastic scattering of 146-MeV. protons by deuterons have been carried out[14]. The results show a forward and a backward rise in the cross section, with a broad valley of about 0·4 millibarns steradian^{-1} between 70° and 140°. They are consistent with recent measurements at Berkeley (effective proton energy 95 MeV.) and at Rochester (240 MeV.).

A proton experiment which lay outside the main programme was the investigation by J. M. Dickson and T. C. Randle[15] of the reaction $^{12}C(p,3p3n)^{7}Be$. They measured the excitation function for the production of beryllium-7, from the threshold (about 30 MeV.) to 160 MeV., using the internal proton beam. A similar experiment has been performed by T. C. Randle, J. M. Dickson and J. M. Cassels[16] on the reaction $^{9}Be(p,p2n)^{7}Be$. Both these reactions have been used to monitor proton bombardments.

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OBITUARIES

Dr. A. E. Cameron

ALFRED ERNEST CAMERON was born in 1887 in Aberdeen and was educated there at Robert Gordon's College and the University, where he graduated M.A. in 1911. He was fortunate in his teachers and supervisors—J. Arthur Thomson at Aberdeen, Sedgwick and Lefroy at the Imperial College of Science and Technology, London, and Hickson and Imms at Manchester. Under these he developed a distinct bent for entomological research, which he confirmed by visiting in 1913, with the aid of a Ministry of Agriculture scholarship, the Entomological Department of the State University of New Jersey and other entomological laboratories in America.

On his return, he occupied in quick succession lectureships in economic zoology in Manchester (1915) and Cardiff (1916), and in the following year was invited to Canada to tackle the pear-thrips outbreak in orchards in Vancouver Island. His success led to his appointment as Government entomologist in the Province of Saskatchewan (1919), and this post was combined in 1920 with the professorship of zoology in the University of the Province, at Saskatoon. On the re-organization of the Department of Zoology in the University of Edinburgh, in view of its new establishment at the King's Buildings, Cameron, partly influenced by the educational requirements of a growing family, returned to Britain in 1928 as lecturer in entomology; and in Edinburgh he completed his life's work, succeeding Dr. C. B. Williams as Steven lecturer in agricultural and forest entomology in 1932, and in 1944 being promoted to a readership.

Dr. Cameron's first important paper was a pioneer work on the relationship of the insect fauna of the soil to its environment, but most of his investigations, in Great Britain and Canada, had some economic bearing. A few of these dealt with insect pests of plants, notably his work on the pear-thrips and its

control; but the majority made valuable contributions to knowledge of the structure, life-history and bionomics of blood-sucking insects, as, for example, his many papers on the Tabanidæ and Œstridæ of Canada and Britain, and his recent collaborative work on Scottish midges.

Cameron was an M.A. and D.Sc. of Aberdeen, and M.Sc., Manchester, and in 1935 he was awarded the Makdougall-Brisbane Medal and Prize of the Royal Society of Edinburgh. Besides his teaching work in the University and Royal (Dick) Veterinary College, he acted as entomological adviser to the Edinburgh and East of Scotland College of Agriculture and consultant to the Royal Highland and Agricultural Society.

In all his teaching and research, Dr. Cameron showed great activity, alertness of mind, and meticulous regard for thoroughness. Struck down by a severe illness more than two years ago, he resigned from his readership in 1951, and died on February 27, 1952. He is survived by his wife and a family of five sons and three daughters.

James Ritchie

Mr. W. G. Campbell

William George Campbell, who died suddenly at Princes Risborough on November 24, 1951, was born at Perth, Scotland, on March 5, 1900. He was educated at Perth Academy and the University of St. Andrews, where he had a distinguished career, obtaining first-class honours in both chemistry (1923) and botany (1924). After a year's research in carbohydrate chemistry under Sir James Irvine, he was awarded a Commonwealth Fund fellowship and commenced work in 1925 at the U.S. Forest Products Laboratory at Madison, Wisconsin. Here he began those studies of wood chemistry and technology which were to constitute his life-work.

While in the United States, Campbell was awarded the M.S. degree of the University of Wisconsin, and at the conclusion of his fellowship he returned to Britain and was appointed to the Forest Products Laboratory of the Department of Scientific and Industrial Research, then occupying temporary quarters in Oxford. It fell to Campbell to draw up the initial programme of research in wood chemistry, to train staff for the work and to design the lay-out of the Chemical Laboratory in the new building at Princes Risborough. From 1930 onwards he was officer-in-charge of the Chemistry Section, with promotion to senior scientific officer in 1936, principal scientific officer in 1945 and senior principal scientific officer on personal merit in 1949. By this time he had made for himself a unique position in the field of wood chemistry and technology, and his advice was eagerly sought by scientific men and industrialists in all parts of the world. In 1944, at the special request of the American authorities, he was included as a member of the Wood Aircraft Research Mission which visited the United States and Canada. He was much in request at international conferences, and only a few weeks before his death he attended as an official British representative the twelfth Congress of the International Union of Pure and Applied Chemistry at New York, and a conference on cellulose chemistry at Appleton, Wisconsin. From the early days of the Commonwealth Fund fellowship, Campbell had acquired a growing appreciation and understanding of the American outlook, and these close ties were further strengthened by his marriage in 1928 to Frances Pendleton, of Winchester, Kentucky, who, with their son, survives him.

Campbell's success was achieved in the face of long-continued ill-health, which caused him over a period of many years much painful suffering, patiently and stoically borne. Under a quiet and modest exterior he possessed an acute mind, not prone to hasty decision but possessing in full measure insight and soundness of judgment. He was a staunch friend and a loyal and unselfish collaborator whose desire always was that the work he had at heart should prosper irrespective of personal aggrandisement. Those who had the privilege of visiting him at the Forest Products Laboratory will not readily forget the warm welcome, the quiet opening of the discussion to the accompaniment of a freshly filled pipe of tobacco, the advice offered so modestly and so unreservedly. Very quickly came the realization that here was someone whose knowledge of everything pertaining to wood was encyclopædic. Furthermore, much of this was the result of work carried out under his advice and direction. His publications comprise more than seventy papers, and cover a wide range of subjects of which only the barest outline can be given in this notice. Prominent among his interests were problems concerning the isolation and characterization of the lesser-known components of wood. These involved many fundamental investigations of analytical methods. Of special interest in this field were his isolation and characterization in 1935 of starches and other related polysaccharides from oak and walnut woods, followed later by the isolation of several wood starches in their original granular state. He made many contributions also to the study of the hemicelluloses and lignin components of woody materials.

Among Campbell's major achievements were his studies of fungal decay of wood. He showed that the brown- and white-rots of timber could be differentiated clearly by chemical methods, and he was the first to classify the white-rots on the basis of the order and mode of their attack on the major components of wood. He was the first also to demonstrate the chemical nature of the decay produced by the *Lyctus* and death-watch beetles, showing that the food of the former is inside the wood cells, whereas the latter can digest all the major components of the wood. In the course of these investigations he made important contributions to our knowledge of the nitrogen metabolism of the death-watch beetle. Much of this work had immediate practical applications, but his main contributions in this respect came during the War. Included among these were his elucidation of the influence of wood on the corrosion of metals and his fundamental work on the urea-formaldehyde resin glues used in the manufacture of laminated wood structures. Campbell became an international authority in this field, and was the first to put forward a workable explanation of the mechanism of the setting reaction for these glues, and of the mechanical behaviour of glued joints under a wide variety of service conditions.

E. L. Hirst

Mr. H. Smith

Harry Smith, or 'Smithy', as he was affectionately called by most of his colleagues, who died on February 29, occupied officially the position of laboratory steward in the Davy Faraday Laboratory of the

Royal Institution from October 1, 1925, until his retirement on August 31, 1951. He was, however, much more than this.

He was born in Burnley on July 23, 1885, the youngest of a large family. His father died when he was one year old, and although he received a sound preliminary education at Burnley Grammar School he was not able to go to a university, and his further education was through night-schools. Before going to the Davy Faraday Laboratory, he had an appointment in the analytical department of the British Dyestuffs Corporation. Once in the Davy Faraday Laboratory, he made himself invaluable. He constructed apparatus that could not be bought; he kept the stores of chemicals and the files of reprints; he taught new research workers the rudiments of vacuum technique and of X-ray methods; he helped to develop the α-ray integrating photometer and the 5- and 50-kW. X-ray equipments, each of the latter being for a time under his sole charge; he assisted with researches on the magnetic properties of crystals, on the compressibility of crystals and on crystal dynamics. Successive workers in the Laboratory came to rely on his judgment, his fund of useful suggestions regarding experimental details, his manual dexterity, his ability to locate 'leaks' and his invariable good humour. When his services were not in demand by someone or other, he carried out useful research work on his own account.

The debt that his colleagues have owed to him has been partly acknowledged in many published papers, and his own research work has been recorded in a series of joint papers in *Nature*, the *Proceedings of the Royal Society*, the *Proceedings of the Physical Society*, the *Journal of Scientific Instruments*, the *Philosophical Magazine* and the *Physical Review*. It is interesting to record that he read one of these papers at the meeting of crystallographers in Cambridge in 1942 which led to the formation of the X-ray Analysis Group of the Institute of Physics.

The sympathy of his many friends will be with his widow and his only son. KATHLEEN LONSDALE

WE regret to announce the following deaths:

Dr. G. W. M. Findlay, president of the Royal Microscopical Society, on March 14, aged fifty-nine.

Mr. P. C. Pope, secretary during 1927–46 of the Institute of Fuel, on March 1, aged eighty.

Dr. Thomas Wayland Vaughan, director during 1924–36 of the Scripps Institution of Oceanography, La Jolla, California, on January 16, aged eighty-one.

NEW FELLOWS OF THE ROYAL SOCIETY

AT the meeting of the Royal Society on March 20, the following were elected to fellowship:

SIR WALLACE AKERS, C.B.E., director, Imperial Chemical Industries, Ltd., distinguished for his technical direction of the atomic energy project during the War and for the building of large research departments and plants in Imperial Chemical Industries.

PROF. C. E. H. BAWN, Grant-Brunner professor of inorganic and physical chemistry, University of Liverpool, distinguished for his researches on chemical kinetics, especially on the mechanism of polymerization, oxidation and hydrocarbon free radical reactions.

PROF. N. J. BERRILL, Strathcona professor of zoology, McGill University, Montreal, distinguished for his analytical studies of development, morphogenesis and regeneration particularly in the Tunicata, on which his monograph, published by the Ray Society, is now the standard British work.

DR. J. H. CRAIGIE, associate director, Science Service, Dominion Department of Agriculture, Ottawa, distinguished for his elucidation of the mechanism of sexual reproduction of the rust fungi and for his studies of the genetics and epidemiology of the cereal rusts; he has made notable contributions to scientific agriculture in Canada.

DR. F. J. DYSON, associate professor of theoretical physics at the Floyd Neuman Laboratory of Nuclear Studies, Cornell University, Ithaca, N.Y., distinguished for his discoveries in the geometry of numbers and for his contributions to quantum electrodynamics.

DR. HONOR B. FELL, Foulerton Research Fellow of the Royal Society, director of the Strangeways Research Laboratory, Cambridge, distinguished for her researches on the development and differentiation of tissues and rudiments of organs *in vitro*; she has made fundamental contributions to knowledge of the mechanisms governing cartilage and bone formation.

DR. D. LL. HAMMICK, Aldrichian praelector in chemistry, University of Oxford, distinguished for his work in physical chemistry, especially in the application of physical methods in the study of organic chemical reactions.

PROF. L. HAWKES, professor of geology, Bedford College, University of London, distinguished for his researches in igneous geology and petrology, especially of Iceland.

DR. W. O. JAMES, reader in botany (plant physiology), University of Oxford, distinguished for his studies in plant physiology, in particular for his contributions to our present understanding of the catalytic mechanisms of respiration in higher plants, and of the relation of respiration to plant syntheses.

PROF. HARRY JONES, professor of mathematics, Imperial College of Science and Technology, University of London, distinguished for his contributions to the theory of the solid state and the detonation processes of solid explosives.

PROF. B. KATZ, professor of biophysics, University College, London, distinguished for his contributions to neurophysiology, particularly in respect of nervous impulses and muscle end-plate potentials.

DR. R. LEMBERG, director, Biochemical Department of the Institute of Medical Research, Royal North Shore Hospital, Sydney, distinguished for his contribution to the study of the metabolism of pigments derived from hæmoglobin; he has initiated new botanical researches through his discovery of pigments of the bile type in plants.

PROF. W. H. MCCREA, professor of mathematics in the University of London (Royal Holloway College), distinguished for his contributions to theoretical astrophysics and cosmology.

PROF. J. S. MITCHELL, professor of radiotherapeutics, University of Cambridge, and director of the

Radiotherapeutic Centre, Addenbrookes Hospital, distinguished for his work in biophysics and radiotherapy; he has materially contributed to our knowledge of the effects of radiation on metabolic processes.

Prof. A. C. Offord, professor of mathematics, Birkbeck College, University of London, distinguished for his contributions to Fourier analysis and the theory of integral functions.

Prof. A. G. Pugsley, O.B.E., professor of civil engineering, University of Bristol, distinguished for his contribution to the reliability of aircraft structures, the design of which has been much influenced by his researches.

Dr. R. R. Race, serologist, Medical Research Council, Lister Institute, distinguished for the application of serological methods in human genetics, and of genetics in medicine; in particular he is principally responsible for the progressive elucidation of the complicated genetical situation found in connexion with the rhesus and other factors capable of causing hæmolytic disease.

Martin Ryle, lecturer in physics, University of Cambridge, distinguished for his leadership of the Cambridge school of radioastronomy.

D. MacL. Smith, chief engineer, Gas Turbine Department, Metropolitan-Vickers Electrical Co., Ltd., distinguished for his contributions to the theory and design of steam and gas turbines and axial flow air compressors, and their applications to aircraft, marine propulsion, the railway locomotive and industrial use.

Prof. F. S. Spring, professor of organic chemistry in the Royal Technical College, Glasgow, distinguished for research in organic chemistry, particularly in the field of sterols, of triterpene resinols and related acids and of heterocyclic compounds with antibiotic activity.

E. W. Taylor, C.B.E., joint managing director of Cooke, Troughton and Simms, Ltd., distinguished for his contributions to the development of optical instruments used in surveying and in phase-contrast microscopy.

Prof. S. Tolansky, professor of physics, Royal Holloway College, University of London, distinguished for his contributions to the fine structure of spectral lines, the determination of nuclear spin, and new types of interference fringes.

Dr. Marthe Vogt, lecturer in pharmacology, University of Edinburgh, distinguished for her work on the quantitative estimation of the cortical hormone in adrenal venous blood, and for her discovery of the various factors which control the output of this hormone.

Prof. T. S. Westoll, professor of geology in the University of Durham, distinguished for his palæontological investigations on Palæozoic fishes and especially on their relationships with the amphibia.

D. D. Woods, reader in microbiology, University of Oxford, distinguished for his contributions to bacterial chemistry and particularly for the explanation of the antibacterial action of sulphonamides; the reversal of this action by para-amino-benzoic acid is a contribution of fundamental importance.

NEWS and VIEWS

University of Manchester

The status of professor of mathematical analysis has been granted to Dr. Kurt Mahler, reader in mathematics in the University.

Among the honorary degrees to be conferred on May 21, those of D.Sc. have been awarded to Dr. W. Lawrence Balls, the authority on cotton, and Prof. A. von Muralt, the physiologist.

Royal Society's Depository of Unpublished Mathematical Tables

Following the decision of the Royal Society to open a depository for unpublished mathematical tables (see *Nature*, 167, 303; 1951), the following tables have been accepted: "Tables for the Plethysm of *S*-Function", by E. M. Ibrahim; "Sines and Cosines of the Decimal Circle", by the Raytheon Manufacturing Co.; "Table de Factorisation des Nombres $2N^2 + 1$", by A. Gloden; "Tables of Fresnel Integrals, Modified Fresnel Integrals, the Probability Integral, and Dawson's Integral", by M. S. Corrington; "Tables des Solutions des Congruences $X^{x^n} + 1 \equiv 0 \pmod{p}$, $n = 4, 5, 6$, $p < 10^4$", by A. Gloden; "Tables of $\int_0^a I_0(a)da$ and $\int_a^\infty K_0(a)da$", by C. Mack and Miss M. Castle; and "Chebyshev Polynomials: Exact Values", by J. C. P. Miller, C. W. Jones, J. F. C. Conn and R. C. Pankhurst. These tables can be consulted in the library of the Royal Society, and photo-copies can be prepared at the expense of those who desire them. Offers of tables for the depository should be addressed to the Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W.1.

World Federation of Scientific Workers

The World Federation of Scientific Workers had proposed to hold a meeting of its Executive Council at Madingley Hall, Cambridge, during March 22 and 23; the Federation was informed by the Home Secretary, however, that no foreign members of the Council would be granted visas or allowed to enter Britain to attend the meeting, which has therefore been abandoned. The World Federation of Scientific Workers consists of sixteen organizations of scientific workers from fourteen countries, including Britain, the United States, the U.S.S.R., China, France and India. It was founded six years ago on the initiative of the Association of Scientific Workers in Great Britain, and is one of the non-governmental international organizations recognized by the United Nations. The World Federation is governed by a general assembly, which meets every two years, decides policy, and elects the chief officers and an Executive Council. There are twenty-two places in the Council, of which sixteen are occupied and six are to be filled. The present officers are: *President*, Prof. F. Joliot-Curie; *Vice-Presidents*, Prof. J. D. Bernal, Prof. C. F. Powell, Prof. Li-Tze-Kwang and Prof. Linus Pauling; *Treasurer*, Dr. W. A. Wooster; *Secretary-General*, Mr. J. G. Crowther (15 Half Moon Street, London, W.1). Since the foundation of the World Federation in London in 1946, the Executive

Council has met on ten occasions: four times in London, five times in Paris and once in Czechoslovakia. Among those who were to have attended the meeting at Cambridge were Prof. F. Joliot-Curie and Dr. Pierre Biquard (France), Academician Vassily Nikitin (U.S.S.R. Academy of Sciences), Madame I. Nikitina, Prof. I. Lebedev (president of the Higher Institutions and Scientific Workers' Union of the U.S.S.R.) and M. Oraevsky; Prof. Tsien San-Tsiang and Dr. Chi Tsin-Jen (Chinese Federation of Scientific Societies); Prof. L. Infeld and Prof. Z. Kuligowski (Polish Federation of Scientific Societies); Prof. I. Malek (Czechoslovakian Association of Scientific Workers), and representatives from India, Britain and the Dominions.

Synthetic Fibres in Prospect and Retrospect

THE second George Douglas Lecture to the Society of Dyers and Colourists, given by Dr. Rowland Hill in Manchester on March 7, was entitled "Synthetic Fibres in Prospect and Retrospect", and in it he gave some impressive figures to illustrate the magnitude of the effort required for the development of a synthetic fibre such as nylon or 'Terylene'. In the early phases an expenditure of 6 million dollars and the services of 230 chemists and engineers were deployed in research and development on nylon in the United States, and a further 21 million dollars were spent before commercial sales were made. To-day, the firm of Du Pont de Nemours has spent 45 million dollars in research alone and 196·8 million dollars on plant and facilities in the development of this single fibre. In Britain, Imperial Chemical Industries, Ltd., has recently completed a plant at Billingham for making five thousand tons a year of nylon polymer, and extensions are already under way to treble this capacity. This is probably the most varied and complex organic chemical plant of its kind in Great Britain, and the design effort alone has necessitated thirty-five design engineer man-years and more than two hundred draughtsman man-years, supported by necessary services. The final drawings totalled about three thousand, and the 29-in. wide printing paper used for taking prints measured about twenty miles, or an area of six acres. Construction spread over three years required about fourteen hundred man-years with a peak of 750 men. The plant contains seven thousand valves, sixteen hundred major instruments and roughly a hundred and fifty miles of 'main-line' piping. The output of five thousand tons of polymer is fed to the spinning factory of British Nylon Spinners at Pontypool, emerging mainly as a continuous-filament nylon yarn, sufficient in length to encompass the earth thirty thousand times. The new plant for making 'Terylene' polyester fibre, upon which a start has been made at Wilton, is estimated to cost about £8 millions.

Handbook of Scientific Instruments and Apparatus

THE annual "Handbook of Scientific Instruments and Apparatus" prepared in connexion with the Physical Society's annual exhibitions and giving details of the exhibits is now well known. This year's Exhibition is being held in the Imperial College of Science and Technology, South Kensington, London, during the period April 3–8; as in previous years, admission is only by ticket. It will be formally opened by the president of the Physical Society, Prof. L. F. Bates, on April 3, at 10 a.m. On this occasion two discourses are to be given: (1) by Mr. B. N. Wallis (Vickers-Armstrongs, Ltd.) on "Engineering Supersonic Aerodynamics", and (2) by Mr. E. R. Davies (Kodak, Ltd.) on "The Physical Basis of Colour Photography". An additional lecture, just announced, will be given by Dr. K. Hickman, of Rochester, New York, an authority on high-vacua physics, who will speak on April 3 at 5.15 p.m. on "Torpidity of Liquid Surfaces". The prize distribution of the Craftsmanship and Draughtsmanship competition is to take place during the Exhibition (3 p.m. on Saturday, April 5). The Handbook for 1952 provides a comprehensive description of the many exhibits to be staged by 150 exhibitors. The exhibits cover a very wide field of physical instruments and materials used in their construction, while the exhibitors include not only industrial firms but also government research establishments and university laboratories. The Handbook is well printed on glossy paper and is profusely illustrated by numerous half-tone reproductions. The volume is essential to all workers interested in the progress and development of scientific instruments (pp. xi+244+A.76. Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7. 6*s.*; postage 1*s.* 3*d.*).

Technical Information and Documents Unit

THE Headquarters Technical Information Service of the Department of Scientific and Industrial Research has been merged with the Technical Information and Documents Unit of the Department and will in future be known by this latter name. The address of the Unit is Cunard Building, 15 Regent Street, London, S.W.1 (telephone, Whitehall 9788). There is a reading room on the third floor of the building, which is open during normal office hours on weekdays and Saturday mornings, and where all inquiries may be directed. The Unit maintains a technical inquiry service and is the British centre for an international questions-and-answers scheme. The object of this scheme is to provide information about industrial techniques from the United States, Canada, France, Germany, Ireland, Sweden and the United Kingdom. It is hoped that the scheme will help to cut out unnecessary delay and expense in the development of production processes. Another function of the Unit is to receive unpublished reports from British and American sources and to issue summaries of them; many of these reports contain information which is not published in the normal way. In addition, the Unit holds the German industrial documents which were taken to Great Britain after the Second World War.

Endeavour Prizes for Science Essays

IN order to induce younger scientific workers to take an interest in the work of the British Association for the Advancement of Science and to raise the literary standard of scientific writing, Imperial Chemical Industries, Ltd., publishers of *Endeavour*, are offering a number of prizes for an essay, not exceeding four thousand words, on one of the following subjects: sulphur in medicine, science, and technology; oceanography; the origin of life; the influence of climate on technology; scientific research in polar regions; and gas discharge tubes. Competitors must be less than twenty-five years old and must send in their essays by June 2. The prizes will be 50, 25 and 15 guineas, respectively, with two special awards of 5 guineas each to competitors less than eighteen, and in addition prize-winners will have expenses paid for attendance at the British Association meeting, which will be held this year in Belfast

during September 3–10. Further details of these awards, which are known as *Endeavour* prizes, can be obtained from the Assistant Secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1.

Society of Public Analysts and Other Analytical Chemists

The seventy-eighth annual general meeting of the Society of Public Analysts and Other Analytical Chemists was held on March 7 in the Meeting Room of the Chemical Society, Burlington House, Piccadilly, London, W.1, with the president, Dr. J. R. Nicholls, in the chair. The financial statement and the report of the Council for the past year were submitted and approved. The membership of the Society was reported as being 1,578—an increase of sixteen since last year. In addition to six ordinary meetings of the Society, there have been sixteen meetings held by its Sections and Groups in the course of the year. At the conclusion of the meeting, the Bernard Dyer Memorial Lecture of the Society was given by the Hon. Sir George Lloyd-Jacob, of the Chancery Division, High Court of Justice. The following officers were elected for the forthcoming year: *President*, J. R. Nicholls; *Past-Presidents serving on the Council*, Lewis Eynon, E. B. Hughes, G. W. Monier-Williams and George Taylor; *Vice-Presidents*, R. C. Chirnside, D. W. Kent-Jones and Eric Voelcker; *Honorary Treasurer*, J. H. Hamence; *Honorary Secretary*, K. A. Williams.

Printing, Packaging and Allied Trades Research Association: Exhibition and Conference

The Printing, Packaging and Allied Trades Research Association is holding a conference and exhibition at the University of Leeds during April 1–2, which will be repeated at the Manchester College of Technology during April 3–4; the exhibition will be open to the public on the first day and restricted to members of the Association on the second, and, in addition, there will be an extra day open to the public at Manchester on April 5. The conference will similarly be divided into sessions which will be open on the first day, and restricted to members on the second. The former will consist of two sessions, on "Research and the Printer" and "Technical Progress", respectively, at which a number of papers will be read. The second day will be devoted to a session on "The Application of Research", followed by a "Brains Trust". Further information can be obtained from the Association at Patra House, Randalls Road, Leatherhead, Surrey.

X-Ray Physics: Symposium in London

A science meeting of the Physical Society will be held during May 2–3 in the Department of Physics, Birkbeck College, Malet Street, London, W.C.1. The meeting will be a symposium on "Recent Developments in the Field of X-Ray Physics". Papers will be delivered by the following: Dr. W. A. Wooster (University of Cambridge), J. Dyson (Associated Electrical Industries, Ltd.), K. Das Gupta (University of Liverpool), R. H. Buteux (Birkbeck College, London), Dr. V. E. Cosslett and W. C. Nixon (University of Cambridge), Prof. Kathleen Lonsdale (University College, London), Dr. W. Ehrenberg and A. Franks (Birkbeck College, London). Visitors wishing to attend this meeting should apply to the offices of the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7, for further particulars.

The Night Sky in April

Full moon occurs on April 10d. 08h. 53m. U.T., and new moon on April 24d. 07h. 27m. The following conjunctions with the moon take place: April 9d. 20h., Saturn 7° N.; April 12d. 11h., Mars 7° N.; April 22d. 16h., Mercury 6° S.; April 23d. 04h., Venus 6° S. In addition to these conjunctions with the moon, Mercury is in conjunction with Venus on April 16d. 19h., Mercury being 1·3° N. Mercury is in inferior conjunction with the sun on April 5 and throughout the month is too close to the sun for favourable observation, and Venus also is unfavourably placed for observation in April. Mars rises at 21h. 50m., 20h. 40m. and 19h. 15m. on April 1, 15 and 30, respectively. The planet is near α Libræ on April 23 and after this date recedes from the star, moving in a westerly direction. Jupiter sets about an hour after the sun on April 1 and is in conjunction with the sun on April 17, after which it becomes a morning star but is too close to the sun for favourable observation. Saturn, a morning star, sets at 6h., 5h. and 4h. on April 1, 15 and 30, respectively, and as its southern declination is very small, it can be easily observed throughout the night and morning hours. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: April 2d. 19h. 58·9m., *A* Gemi. (*D*); April 7d. 20h. 07·5m., 75 Leon. (*D*), *D* referring to disappearance. The Lyrid meteors can be seen from about April 18 to 24, and moonlight will not interfere with observations. Summer time begins on April 20.

"Society for Applied Bacteriology: Winter Meeting"

In a paragraph published in *Nature* of February 23, p. 311, dealing with this meeting, reference is made to a paper by Dr. T. Richards, University of Reading, on the use of night blue or victoria blue for the detection of lipolytic activity of bacteria. These dyes are satisfactory at a concentration of 1 in 15,000, and poured plates (nutrient agar, *p*H 7·8) can be used for isolations from mixed flora and streaked plates for pure culture testing, lipolysis being indicated by a colour change. The temporary inhibition of bacterial growth referred to is of minor significance, and does not detract from the value of the test.

Announcements

The fourth technical trade exhibition of materials and equipment used in the paint, varnish and printing-ink industries, arranged by the London Section of the Oil and Colour Chemists' Association, will be held at the Borough Polytechnic, Borough Road, London, S.E.1, during April 7–9 (2.30–8.30 p.m. each day). Exhibition brochures can be obtained from the honorary secretary, H. C. Wordsall, c/o Plastanol, Ltd., Crabtree Manor Way, Belvedere, Kent.

A symposium on "Biology as a Career" is to be held in the Heriot-Watt College, Edinburgh, under the auspices of the Institute of Biology on April 10. During the morning session, the chair will be taken by Dr. H. B. Nisbet, principal of the College, and during the afternoon session it will be taken by Dr. E. Hindle, president of the Institute. Discussions will follow the reading of papers. Further information can be obtained from the Secretary, Institute of Biology, Tavistock House South, Tavistock Square, London, W.C.1.

A METHOD OF CALCULATING THE THICKNESSES OF THE ICE-SHEETS

By Dr. J. F. NYE
Cavendish Laboratory, Cambridge

ICE-SHEETS, such as those of the Pleistocene epoch and those that now cover Greenland and the Antarctic continent, are in a state of quasi-static equilibrium in which the tendency of the ice to spread laterally and to flow downhill under its own weight is just balanced by the inward shear force exerted by the rock floor. By estimating the magnitude of this shear force, it is possible to make an approximate calculation of the thicknesses of the ice.

We may consider first a slab of ice of large extent and of uniform thickness h resting on a plane bed of inclination α. If the stresses are the same on every cross-section perpendicular to the line of greatest slope, resolution of forces down the slope shows that the shear stress on the bed is

$$\tau = \rho g h \sin \alpha, \qquad (1)$$

where ρ is the density and g is the gravitational acceleration. We now allow the thickness and slope to vary slowly from point to point. Let the surface be of slope α in the region to be considered (taken to be of large extent compared with h), but let the bed now be of slightly different inclination. The lines of greatest slope of the bed and of the surface are not now, in general, in the same vertical plane. The shear stress on a plane drawn parallel to the surface, at a distance h from it, is still given approximately by $\rho g h \sin \alpha$ for any value of α, however small. The shear stress on the bed itself is obtained by making a small rotation of the axes of reference of the stress tensor, the small rotation being that which it would be necessary to apply to the surface to make it parallel to the bed. It follows that, since the bed is not near a plane of principal stress (it is, in fact, close to a plane of maximum shear stress), the shear stress on it is also given approximately by the above expression. Moreover, this shear stress is directed parallel, in plan view, to the line of greatest slope of the surface, which implies in turn that the direction of movement of the ice must also be parallel, in plan view, to the line of greatest slope of the surface. Formula (1) is thus approximately true for a sheet of ice resting on a bed the slope of which changes both in magnitude and direction, provided that the local values of the thickness h and surface slope α are used and that h and α do not change much in distances of order h. For an irregular bed the formula gives the shear stress averaged over areas of linear dimensions of order h.

Calculations on Alpine valley glaciers[1] show that the shear stresses on their beds are between 0·5 and 1·5 bars (1 bar = 10^6 dynes/cm.^{2}). The values are spread by such a comparatively small amount because the rate of strain in ice under a sustained stress depends upon a high power (~ 4) of the applied shear stress[2]; thus sustained shear stresses much smaller than 1 bar produce extremely small rates of strain ($\ll 1$ per year), while shear stresses much greater than this produce very much larger rates of deformation than those existing in glaciers and ice sheets. It may not be far wrong, therefore, to assume for a first calculation that τ is constant (~ 1 bar) over the floor of a moving ice-sheet. (The stipulation that the ice-sheet is moving is necessary, because in the centre of a large ice-sheet of considerable height it is possible that the precipitation is not sufficiently in excess of the wastage by evaporation and melting to keep the mass moving; in such a case a considerably smaller shear stress could exist on the bed, and the height would be determined by meteorological factors rather than in the way considered here.) The pressure at the base of an ice-sheet can reach values of several hundred bars, but, in view of the fact that in other crystalline plastic solids the yield stress is nearly independent of a superposed hydrostatic pressure, it is probable that in ice a pure hydrostatic pressure has a negligible effect upon the shear stress needed to produce a given rate of shear strain.

Equation (1) may be written as

$$h = h_0 \operatorname{cosec} \alpha,$$

or, for small α,

$$h = h_0/\alpha, \qquad (2)$$

where $h_0 = \tau/\rho g$. If $\tau = 1$ bar, $h_0 = 11$ m. We therefore have the very simple result that the thickness of a moving ice-sheet is inversely proportional to its surface slope. This result can be applied to two types of problem.

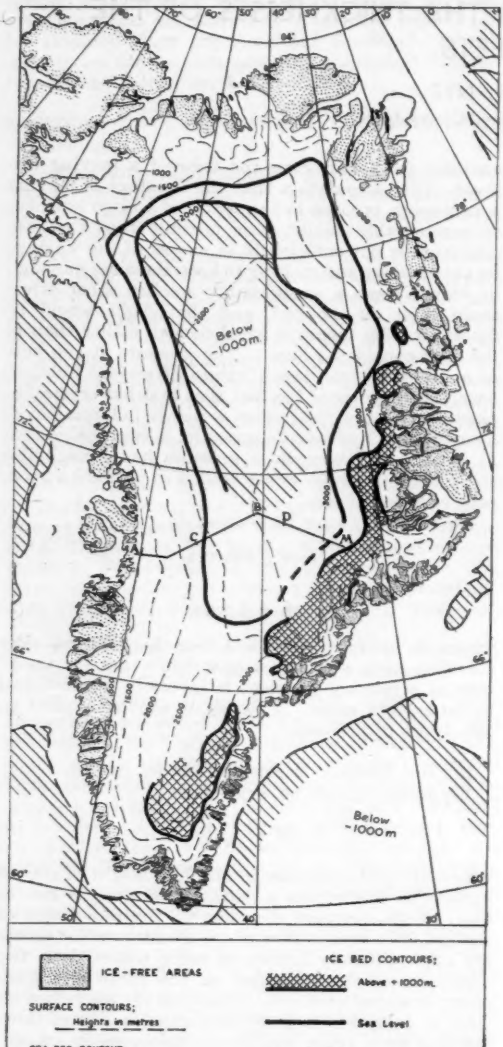
(*a*) *Bed known; to calculate the ice surface.* Equation (2) can be written as

$$\delta H = \frac{h_0}{h}\,\delta s, \qquad (3)$$

where δH is the increase in absolute height of the ice surface as one moves a distance δs along a line of flow, in the opposite direction to the movement of the ice. The lines of flow of the Pleistocene ice-sheets are approximately known in some places from the directions of the striations on the rocks and from other erosional evidence. Equation (3) may then be used to integrate step by step along a line of flow, starting at a point where the thickness is known. (If the integration is started at the edge of the ice-sheet, $h = 0$, the first increment in H should be taken by putting $h = \delta H/2$, so that $\delta H = \sqrt{2h_0\delta s}$, to avoid the infinity that would arise from a straightforward application of the formula.) The successive increases in H are calculated by using for each interval the value of h found by subtracting the height of the bed from the calculated value of H, making allowance as necessary for the depression of the bed by the overlying ice. The profile so found will not be accurate very near the edge, say, within 1 km., where h is changing rapidly.

If the bed is horizontal, $\delta H = \delta h$, and the step by step integration is unnecessary. Equation (3) integrates to the parabola $h = \sqrt{2h_0 s}$, which was obtained by Hill[3] and by Orowan[4] in the special case when the lines of flow in plan view are all parallel; or it can be expressed by the relation

$$\operatorname{grad}(h^2) = 2h_0.$$



Greenland, showing the height of the bed calculated from equation (2) with $h_0 = 10{\cdot}0$ m.

Where the bed is horizontal, therefore, the surface representing h^2 as a function of position is a surface of constant maximum slope. To find the surface for an arbitrary boundary a sand-heap analogy may be used. A sand-heap is made upon a flat base the outline of which is similar to that of the floor of the ice-sheet. The height of the sand at any point then gives, with a suitable constant of proportionality, the square of the height of the ice-sheet at the corresponding point. (Photographs of sand-heaps upon various bases are given by Nádai[5].)

The French expedition in Greenland during 1948–51, led by M. Paul E. Victor, has reported[6] the results of seismic soundings on the line AM shown in the map; from C to D, which is the highest point on this traverse, the floor is practically horizontal and at sea level ($\pm$ 200 m.). These measurements of the floor level, together with the measured ice thickness at C, have been used to integrate equation (3) with a constant value of $\tau = 0{\cdot}88$ bars ($h_0 = 10{\cdot}0$ m.), chosen to give the best fit. The integration extends over a mountain range near A 600 m. in height. The ice surface so calculated between A and B is everywhere within 80 m. of the observed surface; the calculated surface is parabolic from C to B.

(*b*) *Ice surface known; to calculate the bed.*

Equation (2) implies that the height of the bed of an ice-cap can be deduced from observations on its surface only. The map shows the result obtained for Greenland by using the surface contours, which cannot be expected to be very accurate, of the Danish 1938 survey map (1 : 5,000,000). τ has been assumed to be 0·88 bars everywhere. Owing to the uncertainties in τ and α, only the broad features are significant. In the north a large area of floor appears to be below sea level. With the above value of , one calculates a maximum depth of 4,200 m. below sea-level. Even if the value of τ is reduced to 0·5 bars, the lowest point is still 1,200 m. below sea level, and so, although the depth may not be as much as 4,200 m., the existence of a considerable depression seems probable. The seismic soundings planned in this area by the British North Greenland Expedition leaving this summer under Commander (L) C. J. W. Simpson, R.N., are awaited with interest.

I wish to thank Mr. W. M. Lomer for his helpful suggestions on the presentation of these results.

[1] Nye, J. F., *J. Glaciol.* (in the press).
[2] Glen, J. W., "Experiments on the Plastic Deformation of Ice", submitted to *J. Glaciol.*
[3] Nye, J. F., *Proc. Roy. Soc.*, A, **207**, 554 (1951).
[4] Orowan, E., *J. Glaciol.*, **1**, 231 (1949).
[5] Nádai, A., "Plasticity", Chapter 19 (McGraw-Hill, 1931).
[6] Joset, A., Expéditions Polaires Françaises. Rapport prélim. de la Section Sondages Séismiques 1951, read by J. Martin at the 1951 Conf. Int. Comm. on Snow and Ice (Brussels).

CHANGES IN THE CROSS-STRIATION OF MYOFIBRILS DURING CONTRACTION INDUCED BY ADENOSINE TRIPHOSPHATE

By Dr. JEAN HANSON

Medical Research Council Biophysics Research Unit, King's College, London, W.C.2

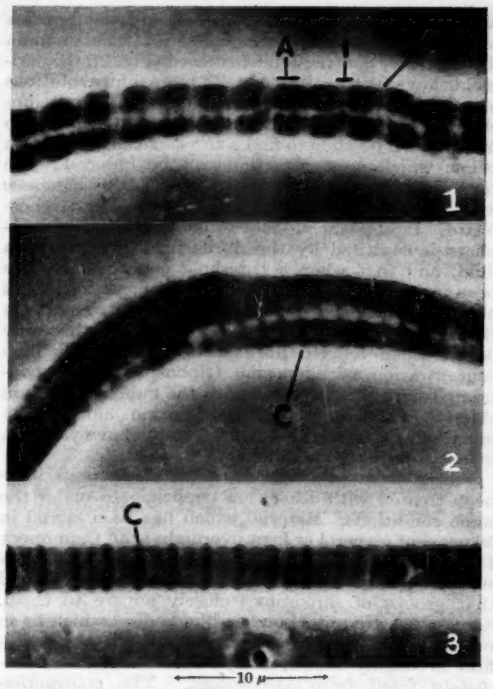
MANY of the observations which laid the foundations of our knowledge of muscle cytology were made on the large myofibrils (sarcostyles) which can easily be teased, with fine needles, out of the fresh thoracic muscles of many insects. It is much more difficult[1] to isolate myofibrils from the muscles of vertebrate animals. For most cytological work on such muscles it has been necessary in the past to use fixed and sectioned material. This is unfortunate, because biochemists and physiologists nearly always choose mammalian or amphibian muscles for their experiments. Recently, however, Schick and Hass[2] and Perry[3] have devised methods for isolating fibrils from fresh mammalian muscle

fibres by treatment with dilute trypsin or collagenase solutions followed by mechanical disruption in a Waring blendor. Morphologically, these fibrils appear to have suffered little damage, and Perry[3] has found that their adenosine triphosphatase activity is unimpaired. These 'living' myofibrils are of a suitable size for observation at the highest magnifications of the light microscope, and some are suitable for electron microscopy. Thus it is now much easier to make an experimental approach to many problems of muscle cytology, particularly to the new problems raised by the important advances in muscle biochemistry made during the past few years.

It is generally believed[4] that the dephosphorylation of the nucleotide adenosine triphosphate to adenosine diphosphate is an energy-releasing event intimately concerned in muscular contraction; further, that myosin, one of the chief structural proteins of muscle, is the enzyme responsible for this reaction. The effects of treating whole muscle fibres or preparations of muscle proteins with adenosine triphosphate have been widely studied[4]; and Schick and Hass[2] and Perry[3] have reported that adenosine triphosphate induces myofibrils to shorten and thicken. More recently, Ashley *et al.*[5] have described the appearance in the electron microscope of myofibrils fixed at various stages during contraction induced by adenosine triphosphate. They have produced evidence that such contraction is accompanied by changes in the pattern of cross-striations. It is widely believed that similar changes in the bands of striped muscles take place during contraction *in vivo*[6], although this has been denied by Buchthal[7] and others. Before my attention was directed to the recent paper of Ashley *et al.*[5], I had found that it is possible to watch, in a phase-contrast microscope, the changes in band-pattern that take place when myofibrils contract during treatment with adenosine triphosphate. These observations form part of a more extensive investigation of myofibrils, and will be published in full elsewhere. The phases of contraction are being studied in more detail by means of ciné-photomicrography.

Myofibrils were prepared from the thigh muscles of rabbits and rats by treatment with trypsin[2] followed by agitation in a blendor. Myofibrils from rabbits, rats and frogs were also obtained by mechanical disruption of thigh muscles stored at 0° C. in a mixture of equal volumes of glycerol and distilled water[4]. Fibrils from the flight muscles of the beetle *Dytiscus* (several species) were isolated by teasing the fibres with fine needles. The sodium salt of adenosine triphosphate was prepared by the method of Bailey[8] from the barium salt obtained from Light and Co., Ltd. Another sample of sodium adenosine triphosphate was kindly given to me by Dr. S. V. Perry. Various quantities of the adenosine triphosphate solution were added to a Palitzsch borax–boric acid buffer (stock solutions: $M/20$ borax, $M/5$ boric acid) of *p*H 6·9 containing 0·1 M potassium chloride and 0·001 M magnesium chloride. The experiments were performed at room temperature (about 20° C.) with mixtures containing between 0·001 M and 0·0001 M adenosine triphosphate. The technique and results of a typical experiment are as follow:

A drop of a suspension of rabbit myofibrils in 50 per cent glycerol was examined in a phase-contrast microscope with a × 95 objective of N.A. 1·3, and a suitable fibril selected and photographed (Fig. 1). A drop of 0·0001 M adenosine triphosphate solution was placed at one edge of the coverslip and drawn through the preparation by means of filter paper placed at the opposite edge. The fibril contracted slowly (about 10 sec.) to about 57 per cent of its original length, and its width increased. (Perry[3] has found that the volume of rabbit myofibrils does not change appreciably during contraction induced by adenosine triphosphate.) Before treatment, the fibril had well-marked anisotropic (A) and isotropic (I) bands (respectively black and white in positive phase-contrast illumination), with black Z lines (2·6 μ apart), and with a white line in the middle of each A band. During the earliest phase of contraction the I bands rapidly disappeared; the fibril became uniformly dark grey in colour and no bands could be distinguished in it. Then a series of sharply defined black lines, the contraction (C) bands, appeared. The zones between the C bands became progressively paler, and further contraction brought the C bands closer together. The fully contracted fibril had a simple pattern of narrow C bands, 1·5 μ apart (Fig. 2).



Photomicrographs of myofibrils in phase-contrast illumination. *A*, anisotropic band; *I*, isotropic band; *C*, contraction band. Fig. 1. Rabbit myofibrils in glycerol. Fig. 2. The fibrils shown in Fig. 1 after contraction induced by adenosine triphosphate. Fig. 3. *Dytiscus* fibril immediately after isolation from living beetle

Similar results were obtained with glycerol-treated rat and frog fibrils, and with rabbit and rat fibrils isolated by the use of trypsin. In some earlier experiments, rabbit fibrils in glycerol were irrigated first with the buffer–potassium chloride–magnesium chloride solution alone, and then with a 0·001 M sodium adenosine triphosphate solution in distilled water. Fibrils induced to contract under these conditions continue to shorten until they become small nodules in which no C bands can be recognized; frequently several nodules are formed from one fibril and are connected with each other by fine strands. When lower concentrations of adenosine triphosphate

are used, the whole fibril contracts in what appears to be a more normal manner, and the *C* bands remain distinct after contraction has ceased (Fig. 2). Experiments have been performed with more dilute solutions of adenosine triphosphate in the buffer–potassium chloride–magnesium chloride mixture, and it has so far not been possible to find a threshold concentration below which no contraction can be induced; the time that elapses before contraction begins increases with decreasing concentration of adenosine triphosphate. It appears probable that adenosine triphosphate is captured by the fibrils from the irrigation fluid, and that when a threshold concentration has been accumulated in the fibrils contraction takes place. Continued irrigation does not result in the formation of disorganized nodules; this only occurs when relaxed fibrils are exposed to a high concentration of adenosine triphosphate. If contracted fibrils are irrigated with the buffer–potassium chloride–magnesium chloride solution alone, they remain unchanged. No other attempts have yet been made to induce relaxation.

Fibrils from the flight muscles of *Dytiscus* have been treated with adenosine triphosphate under the same conditions. Material which has been stored in 50 per cent glycerol or kept overnight at 0° C. in insect Ringer solution does not contract; but fibrils taken straight from a living beetle will contract provided that groups of sarcosomes closely adhere to them. Sarcosomes are mitochondria-like bodies[9] which lie in rows between the fibrils in the intact fibre. When a fibre is roughly teased, many of the fibrils are incompletely freed from sarcosomes. The contraction induced by adenosine triphosphate begins in the vicinity of the sarcosomes and then spreads slowly along the rest of the fibril. Fibrils denuded of sarcosomes do not contract, although many free sarcosomes lie in the fluid around them. Experiments are in progress to elucidate the part that sarcosomes play in contraction induced by adenosine triphosphate. Gilmour[10] has made the relevant observation that much of the adenosine triphosphatase activity of grasshopper muscle appears in the supernatant fluid during the early stages in the purification of myosin. This does not happen to any great extent during the purification of mammalian myosin, and a well-washed suspension of rabbit or rat myofibrils readily contracts when treated with adenosine triphosphate.

Fibrils examined immediately after they have been isolated from a living beetle already have contraction bands (Fig. 3). These are widely spaced, and in the middle of the grey zone between each pair of *C* bands are two darker bands. During contraction induced by adenosine triphosphate, these subsidiary bands disappear and the *C* bands are brought closer together. Fibrils with the band-pattern characteristic of the relaxed state are found only in material examined several hours after removal from the beetle; preliminary experiments on this material suggest that adenosine triphosphatase activity has already been lost because, even in the presence of sarcosomes, these relaxed fibrils will not contract when treated with adenosine triphosphate. It is too early to discuss how the peculiarities in the response of insect flight fibrils to treatment with adenosine triphosphate are related to the physiological peculiarities of insect flight muscles discovered by Pringle and others[11].

The number of contraction bands in a mammalian myofibril after treatment with adenosine triphosphate is the same as the number of sarcomeres in the fibril before treatment. By watching fibrils which initially had *Z* lines at their broken ends, I conclude that the *C* bands probably appear in the former positions of the *Z* lines. Jordan (reviewed in ref. 6) and others[6,12] have reached similar conclusions by studying the band-patterns of muscles fixed in the relaxed state or during tetanic contraction; they have also described examples where one part of a fibre appears to have been arrested in the contracted state while adjacent regions are apparently relaxed. In his review, Jordan[6] has suggested that during the earliest phase of contraction the material of the *A* band separates into two masses which then migrate away from each other and accumulate around the *Z* lines bounding the sarcomere, to form *C* bands. This conception needs to be modified if one considers that the band-changes during contraction induced by adenosine triphosphate are the same as those taking place during contraction *in vivo*. It appears that the material of the *A* band first spreads out uniformly throughout the fibril and later accumulates in *C* bands, which correspond in position to the former *Z* lines. However, these early phases of contraction are rapid, and await closer investigation by means of high-speed ciné-photography.

Suspensions of isolated fibrils from vertebrate muscles and from insect flight muscles contain examples with various band-patterns, some with *A* and *I* bands, and others with *C* bands, widely spaced or close together. It is interesting that one never finds fibrils with uniformly distributed *A*-band material, that is, arrested mid-way between relaxation and contraction, although after *C* bands are formed further contraction can apparently be arrested at any stage. It is possible that the later stages of contraction are rarely found *in vivo*, where muscle fibres do not contract under completely isotonic conditions. Indeed, the attachments of insect flight fibres to the thoracic exo-skeleton are such that contraction must be nearly isometric[11]. We know little about the changes that take place in the cross-striation of muscles contracting *in vivo*. Buchthal and his collaborators[7] have obtained photographs, taken in ordinary light, of whole isolated frog fibres contracting during direct electrical stimulation, and have concluded that there is no change in band-pattern. During isotonic contraction, they reported that both the *A* and the *I* bands decreased in width (measured along the length of the fibre); during isometric contraction the *A* bands became narrower and the *I* bands wider. The optical artefacts inherent in observing whole fibres make it difficult to evaluate these results; but the photographs do not rule out the suggestion that the unstimulated fibres used in these experiments already possessed contraction bands, and the changes seen during contraction represented alterations in the widths of these *C* bands and the intervening zones. Isolated vertebrate and insect myofibrils which already have *C* bands will contract further when treated with adenosine triphosphate. When isolated mammalian myofibrils with the 'relaxed' band-pattern (*A*, *I*, *Z*) are treated with adenosine triphosphate, the changes leading to the 'contracted' pattern (with *C* bands) appear to take considerably longer than the time elapsing between electrical stimulation of a whole muscle fibre and the attainment of maximal contraction in a single twitch. It is necessary to consider the possibility that the extensive rearrangements of the pattern of striations that occur when 'relaxed' fibrils are treated with adenosine triphosphate may not be

manifested during a muscle twitch. They may, however, be rearrangements that are necessary before a muscle fibre is brought into a state responsive to stimulation.

I am much indebted to Prof. J. T. Randall for his encouragement of this investigation and for the facilities he has provided in this laboratory. I am also grateful to Dr. H. B. Fell for discussion of the results. [Dec. 12.

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DIAMINOPIMELIC ACID AND LYSINE

Diaminopimelic Acid Decarboxylase

SPECIFIC decarboxylases for seven amino-acids have been found in bacteria[1]. The amino-acids which are decarboxylated all possess a free ω-polar group in addition to the terminal carboxyl and α-amino groups. The diamino dicarboxylic acid, α-ε-diaminopimelic acid,

$$COOH.CH(NH_2).(CH_2)_3.CH(NH_2).COOH,$$

recently isolated from certain bacteria[2], is another example of such an amino-acid. We are now reporting its decarboxylation to lysine and carbon dioxide by certain strains of *Escherichia coli*, an organism in which we have found the amino-acid[3].

The test organisms were acetone-dried cells, harvested after 12–16 hr. growth at 37° on the following medium (shown by paper chromatography to contain no diaminopimelic acid): peptone 1 per cent, lab. 'Lemco' 1 per cent, sodium chloride 0·5 per cent, glucose 2 per cent. Decarboxylase activity was demonstrated both manometrically by measurement of carbon dioxide evolution at *p*H 7·0, and by paper chromatography (Fig. 1). Every strain of *E. coli* grown on peptone broth which was found to decarboxylate diaminopimelic acid also had lysine decarboxylase activity, which was apparent even at *p*H 7·0 (see table), a far more alkaline reaction than the optimal *p*H (4·5–5·0) for lysine decarboxylase. Consequently, the lysine formed from diaminopimelic acid was further decarboxylated to cadaverine, and the carbon dioxide measured was the sum of the two decarboxylase activities.

Diaminopimelic acid decarboxylase resembled the other bacterial amino-acid decarboxylases in many respects. It was more active in cells grown on an acid medium or in the presence of glucose (which is fermented to acid-reacting products); thus, the activity of cells grown at *p*H 5·5 was seven times that of cells grown at *p*H 8. Acetone-dried cells required additional pyridoxal phosphate for maximum

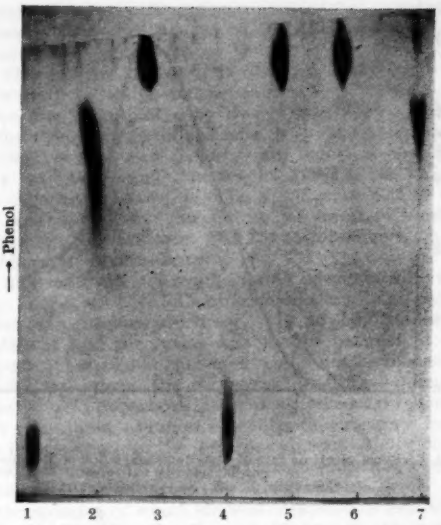

Fig. 1. Descending chromatogram in phenol (ammonia atmosphere), showing products of decarboxylation of diaminopimelic acid and lysine by *E. coli* (No. 1). After 2 hr. incubation under the same conditions as in the table, 0·2 ml. 10 per cent trichloroacetic acid added and 20 μl. of supernatant put on paper. α-ε-Diaminopimelic acid 20 μgm. (1); lysine 20 μgm. (2); cadaverine 20 μgm. (3) are controls. With cells boiled for 10 min., added diaminopimelic acid remained unchanged (4). With unboiled cells, diaminopimelic acid was completely decarboxylated to cadaverine (5), lysine was also decarboxylated to cadaverine (6). With cells grown on an amino-acid free medium, no lysine decarboxylase was present, and decarboxylation of diaminopimelic acid stopped at lysine (7)

decarboxylation activity, suggesting that this substance is a coenzyme; but no increase in activity resulted from addition of pyridoxin to the growth medium. Activity varied greatly with time of growth, declining rapidly after maximum growth was attained, the activity after 17 hr. incubation at 37° being less than 30 per cent of that at 12 hr. Diaminopimelic acid decarboxylase differed from the majority of bacterial decarboxylases, which are adaptive enzymes, in that it was produced when the organisms

DECARBOXYLATION AT 38° OF NATURAL DIAMINOPIMELIC ACID AND L-LYSINE BY *E. coli*

Contents of Warburg flasks: main compartment, 40–50 mgm. acetone-dried cells in 1 ml. water + 1 ml. 0·5 *M* phosphate buffer, *p*H 7·0; side bu b, 0·5 ml. *M*/30 amino-acid. Atmosphere: air

Strain	Growth medium	Carbon dioxide evolved (μl./hr./mgm. dry cells)	
		from α-ε-diaminopimelic acid	from lysine
1. Local hospital strain	glucose salt (ref. 5)	5	0
1. " " "	peptone broth	6	3
2. " " "	" "	1	12
4. " " "	" "	3	25
5. " " "	" "	0	0
NTCC 86	" "	0	5
NTCC 7020 Standard strain for arginine decarboxylase (ref. 4)	" "	0	0
ATCC 9637 Parent strain for mutants	" "	3	16
81–83, 26–26, 81–47 Lysine-requiring mutants	peptone + lysine	0	10–16
173–25 Mutant requiring α-ε-diaminopimelic acid and lysine	peptone + α-ε-diaminopimelic acid + lysine	3	20

Fig. 2. Effect of *p*H on rate of total decarboxylation of diaminopimelic acid
——— acetone-dried *E. coli*; - - - - cell-free extract

were grown in the absence of substrate, addition of diaminopimelic acid to the growth medium having little or no effect on decarboxylase activity. The optimum *p*H for total decarboxylation of diaminopimelic acid to cadaverine was 7·2, both for acetone-dried cells (Fig. 2) and for cell-free preparations obtained by extracting disintegrated cells with *M*/30 phosphate buffer, *p*H 7·0.

The possibility that decarboxylation of diaminopimelic acid might be carried out by lysine decarboxylase and not by a specific diaminopimelic acid decarboxylase was excluded by the following observations. The *p*H optima differ by about 2 units. The relative degrees of decarboxylation of the two amino-acids varied from strain to strain, and with conditions of growth (see table). Thus, of eight wild-type strains of *E. coli* grown on peptone broth and examined for decarboxylase activity at *p*H 7, the majority decarboxylated lysine faster than diaminopimelic acid; but in one strain (No. 1), however, the relative activities were reversed, and in another strain no diaminopimelic acid decarboxylase activity was apparent although lysine decarboxylase was present. In two strains neither enzyme could be detected. Strain No. 1, grown on an amino-acid free glucose-salt medium[5], had lost its lysine decarboxylase activity, but its diaminopimelic acid decarboxylase activity was almost unchanged (see also spot 7, Fig. 1). We have examined two types of mutants of *E. coli* and their parent wild strain[6], kindly provided by Dr. Bernard D. Davis; diaminopimelic acid decarboxylase was present in the parent strain and in a mutant requiring diaminopimelic acid and (to a lesser extent) lysine, but was absent from three lysine-requiring mutants. Lysine decarboxylase was present in both types of mutants and the parent strain.

It should be pointed out that the manometric method of testing is not sufficiently sensitive to detect very low decarboxylase activity, and the figure 0 simply implies an absence of detectable activity. This apparent absence of diaminopimelic acid decarboxylase must be confirmed by a more sensitive method, such as that used for aspartic acid decarboxylase[7]; in the case of the lysine auxotrophs, the absence of the enzyme is made more likely by the finding of Davis[6] that the amino-acid accumulates in the growth medium.

There was no detectable difference in the strength of diaminopimelic acid spots on chromatograms[3] of acid hydrolysates from five strains of *E. coli* grown on glucose peptone broth, although only three strains contained appreciable amounts of the decarboxylase.

Since diaminopimelic acid decarboxylase is a constitutive enzyme, and its substrate is necessarily present in the cell, these results, together with those reported by Davis[6], suggest that diaminopimelic acid could be an intermediate in lysine synthesis in *E. coli*. The virtual absence of diaminopimelic acid decarboxylase from the lysine auxotrophs supports this conclusion, and is one of the few examples in which auxotrophic mutation has been shown to be accompanied by loss of enzyme activity.

We are greatly indebted to Dr. Bernard D. Davis for cultures of bacterial mutants, to Dr. E. F. Gale for other cultures and to Dr. W. W. Umbreit for a generous gift of pyridoxal phosphate.

D. L. Dewey
Elizabeth Work

Department of Chemical Pathology,
University College Hospital Medical School,
London, W.C.1.
Oct. 31.

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Biosynthetic Interrelations of Lysine, Diaminopimelic Acid, and Threonine in Mutants of *Escherichia coli*

α-ε-Diaminopimelic acid has been isolated from bacteria[1,2] and found to be decarboxylated to lysine and carbon dioxide by an extract of *Escherichia coli*[3]. The enzyme responsible, in contrast to several other bacterial amino-acid decarboxylases, is constitutive rather than adaptive; furthermore, it is absent from certain lysine auxotrophs[3]. The present communication reports observations which, together with the above facts, suggest that diaminopimelic acid functions not only as a structural component of the cell, but also as a precursor of lysine.

Using a sample of natural α-ε-diaminopimelic acid generously furnished by Dr. Elizabeth Work, we isolated mutant 173-25 from *E. coli* strain *W* (*ATCC* 9637) by means of the penicillin method[4,5]. On minimal medium *A*[6] at 35° C., this mutant has an absolute requirement for diaminopimelic acid together with a relative requirement for L-lysine; its growth is slow on diaminopimelic acid, even in concentrations up to 200 μgm./ml., but rapid on lysine plus diaminopimelic acid. In this mixture the lysine requirement for optimal growth on solid media is about 20 μgm./ml., like that of mutants requiring lysine alone; the diaminopimelic acid requirement is 5 μgm./ml. The latter requirement is smaller than that for any other amino-acid, except tryptophane, in the corresponding auxotrophs of *E. coli*.

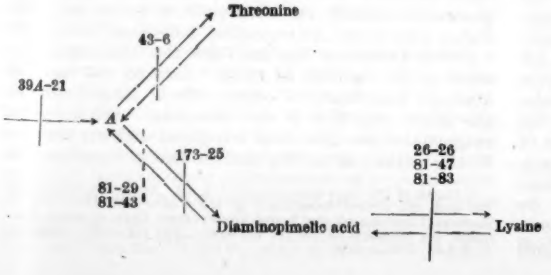
Though strain 173-25 does not grow on lysine alone, even in high concentrations, it gives rise to

secondary mutants (for example, 173-25C3) which do grow, though slowly, on lysine as well as diaminopimelic acid; they grow more rapidly on a mixture of the two. Some of these secondary strains, when growing on lysine, are accelerated by incubation in 5 per cent carbon dioxide, as might be expected if the decarboxylation is reversible. They are not further accelerated by the addition of pyridoxal (cf. refs. 7, 3).

Strain 173-25 is stable enough to be used in turbidimetric assay for diaminopimelic acid, but the determination is complicated by the fact that an excess of lysine is inhibitory, the optimal concentration of lysine varying with the concentration of the acid. This strain is suitable, however, for qualitative identification of diaminopimelic acid; thus in detecting chromatographic spots of the acid on paper, bioautography[8] with plates of solid medium supplemented with lysine and seeded with strain 173-25 is more sensitive and more specific than ninhydrin.

Following these observations, all our previously isolated lysine auxotrophs were further studied, and were found to fall into two groups with respect to diaminopimelic acid. Strains 26-26, 81-47 and 81-83 respond to lysine only and accumulate diaminopimelic acid in large amounts (300 mgm./l.) in their culture filtrates. Strains 81-29 and 81-43 respond well to lysine and slightly more slowly to diaminopimelic acid; they also grow slowly on minimal medium, indicating an incomplete block. (The diaminopimelic acid or lysine requirement of these two strains is converted from a relative to an absolute one by L-aspartic acid (20 μgm./ml.). Further suggestion of an inhibitory relation between these substances is furnished by another strain, 122-64, which requires aspartic acid plus either diaminopimelic acid or lysine.) Of strains 81-29 and 81-43, the latter accumulates L-threonine, as do strains 173-25 and its derived 173-25C3, whereas the former does not. The accumulated compounds were identified by comparison of culture filtrates and pure samples with respect to microbiological activity, stability to autoclaving in acid or alkali, and paper chromatography with four solvents, using both ninhydrin and specific microbiological response to locate the spots.

Additional evidence of a metabolic relationship among these three amino-acids is provided by mutant 39*A*-21, which grows rapidly on L-threonine and slowly on diaminopimelic acid or L-lysine. In contrast, another L-threonine auxotroph, 43-6, shows no response to diaminopimelic acid or lysine. None of the mutants reported here responds to, or is inhibited by, 10-300 μgm./ml. of DL-α-aminoadipic acid (kindly furnished by Dr. H. K. Mitchell) or DL-α-amino-ε-hydroxycaproic acid (kindly furnished by Dr. G. T. Lewis), which satisfy the lysine requirement of certain *Neurospora* mutants[9,10]. D-Lysine (kindly furnished by Dr. J. P. Greenstein) is also inactive.



These facts suggest that diaminopimelic acid is a precursor of lysine (cf. scheme below). This interpretation is supported by Dewey and Work's demonstration[3] that diaminopimelic acid decarboxylase is present in wild-type *E. coli* strain *W*, but absent from the specific lysine auxotrophs (26-26, 81-47 and 81-83) derived from it. The significance of this fact is emphasized by the failure of another kind of mutation (for example, 173-25) to interfere with the production of this enzyme[3].

Alternatively, our results would be compatible with the origin of both diaminopimelic acid and lysine from a common precursor, 173-25 being blocked before it and the lysine auxotrophs between it and lysine. This scheme, however, could not be reconciled with the results of the enzyme studies unless diaminopimelic acid decarboxylation is a multi-step reaction, the postulated common biosynthetic precursor being an intermediate in the decarboxylation. Many of the observations could also be explained if diaminopimelic acid and lysine arose by independent paths the intermediates of which showed competitive inhibition (cf. refs. 11, 12); but this scheme would not explain either the alternative growth responses to diaminopimelic acid or lysine, or the observations on diaminopimelic acid decarboxylase.

The accumulations and growth responses here described therefore reinforce the enzyme studies in leading to the conclusion that diaminopimelic acid is a precursor of lysine in *E. coli*. The isolation of lysine auxotrophs, presumably blocked in a single reaction, further implies that there is only one path of lysine synthesis in this organism, at least under the experimental conditions employed.

In the accompanying scheme the incompletely blocked strains 81-29 and 81-43 are considered to be blocked, like 173-25, somewhere between the postulated compound *A* and diaminopimelic acid. However, since strain 81-29 does not excrete threonine and the other two do, these strains are unlikely all to be blocked in the same reaction. The alternative response of strain 39*A*-21 to any of the three amino-acids suggests that the indicated reactions are reversible, while the specific threonine requirement of strain 43-6 implies a block after the postulated common precursor.

If this scheme be correct, the relative requirement for lysine of strain 173-25 (which requires diaminopimelic acid) would be a secondary effect, possibly due to partial inhibition by a metabolite accumulated before the genetic block. A precedent for partial or even complete inhibition of this type has been found in one group of mutants, blocked in aromatic synthesis, in which an accumulated precursor prevents completely, by competitive inhibition, growth on a later intermediate in the same biosynthetic sequence[13].

Neurospora crassa apparently differs from *E. coli* in its path of lysine synthesis, since various lysine auxotrophs of *Neurospora* fail to respond to diaminopimelic acid[14] and do respond to certain six-carbon compounds[9,10] that were noted above to be inactive for *E. coli*. This appears to be the first instance in which the two organisms are shown to employ different routes in the synthesis of the same amino-acid. It is also noteworthy that diaminopimelic acid, though present in hydrolysates of *E. coli*[15] and many

other bacteria[1], could not be detected in *Neurospora*[15]. This distribution suggests that the path of lysine synthesis via diaminopimelic acid might have selective advantage over the alternative path only when the latter is also required as a structural component. The evolution of two paths of lysine biosynthesis therefore appears to be an understandable exception, among the amino-acids, to the unity of biochemistry.

It is a pleasure to acknowledge the technical assistance of Virginia C. Littau and Elizabeth S. Mingioli.

Bernard D. Davis

U.S. Public Health Service,
Tuberculosis Research Laboratory,
Cornell University Medical College,
New York 21, N.Y.

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SYSTEMIC INSECTICIDES AND SWOLLEN SHOOT DISEASE OF COCOA

In a previous note in these columns (*Nature*, **167**, 260; 1951) we recorded the production by Messrs. Pest Control, Ltd., Harston, Cambridge, of a new systemic insecticide, *bis*(*iso*propylamino)fluorophosphine oxide, which was claimed to be safe for widespread use by the amateur gardener. Further experience has shown that this material has very dangerous toxic properties, and it is now recommended that it be applied only in the form of capsules inserted in the soil and applied *only* to ornamental plants.

As reported in two recent communications in *Nature* (**169**, 120 and 334; 1952) it has been found that this same method of application, on a much larger scale, is highly successful in killing the mealybugs which transmit the virus of swollen shoot disease of cocoa in West Africa. The insecticide used in this case is termed 'Hanane', and it is now disclosed that this is, in fact, a mixture of the two well-known phosphorus insecticides produced by Schrader, *bis*(dimethylamino)fluorophosphine oxide and *bis*(*bis*-dimethylamino) phosphonous anhydride.

The proposed plan is to apply this material to the roots of all those cocoa trees surrounding a focus of infection, which, under the cutting out procedure, would be immediately destroyed. It is hoped that in this way the spread of the infection may be arrested and trees that would otherwise have been sacrificed may be saved. Only those trees which later show signs of the disease would be cut down. The systemic insecticide would not be used alone but in conjunction with cutting out. The whole procedure would have the political advantage of being more readily acceptable to the cultivator and being applicable by untrained persons.

So far there is no evidence available that these operations will, in fact, prevent the spread of the disease, the virus of which exists not only in the cocoa, but also in many of the forest trees around. It is only too well known that the virus diseases of plants may continue to spread even when apparently good control of the vector has been secured. But if the cocoa-growing industry of West Africa is to be saved, it is well worth while making an experiment. In order to do this on a grand scale, the Government of the Gold Coast has given a contract to Messrs. Pest Control, Ltd., for the supply of £500,000 worth of 'Hanane'. To launch an experiment on this scale is a remarkable act of faith, the outcome of which will be watched with the greatest interest.

STELLAR PARALLAXES DETERMINED AT THE CAPE OBSERVATORY

Vol. 16 of the "Annals of the Cape Observatory" contains the data for the determination of the parallaxes of 619 stars from photographs taken with the 24-in. photographic refractor of the Cape Observatory*. Earlier results given in the "Annals" are as follows: Vol. 14, Part 1, 217 stars; Vol. 14, Part 3, 201 stars; and Vol. 15, 592 stars. The basis of selection of the stars was their credited large proper motion, and most of those contained in the present volume have a proper motion exceeding 0·20″, but a few stars of later type with a smaller proper motion have been included. Owing to the fact that the copy for the press was not all available at once, the data are given in three sections, the first including stars numbered 1011 to 1421, the parallaxes for which were originally given in four lists in *Monthly Notices of the Royal Astronomical Society* during 1941–45. The parallaxes for stars numbered 1422–1523, the second series, appeared in the *Monthly Notices* in 1947, but those in the third series, numbered 1524–1624, are still awaiting publication by the Royal Astronomical Society.

The stars are arranged in order of right ascension for 1900·0, and only one name, selected as the most convenient for the identification, has been given to each star. The photographic magnitudes are new determinations made by comparison with standard stars in the *E* regions at declination − 45°. In the case of stars brighter than magnitude 5, the magnitudes generally depend on observations made with the Fabry lens of the Astrographic Telescope, though the Victoria Telescope was used for the observations of some of the faintest of these. Late in the work an attempt was made to obtain visual magnitudes for the stars, but this is not complete. Where visual magnitudes are new they are given without brackets in the catalogue at the end of the publication (pp.

* Annals of the Cape Observatory, Vol. 16: Stellar Parallaxes (6th, 7th and 8th Series) determined in the Years 1937–1948 with the Victoria Telescope of the Royal Observatory, Cape of Good Hope, under the direction of Dr. J. Jackson. Pp. viii+331. (London: H.M.S.O., 1951.) 30*s*.

319–331), those from other sources being given in brackets.

Other sources used include the "Henry Draper Catalogue", or its manuscript revision by Dr. H. Knox-Shaw, and the "Albany General Catalogue". Among magnitudes frequently quoted some very large errors have been found, and in nearly all cases where an accurate photographic and visual magnitude is available the colour index agrees to within 0·1 magnitude with the mean value for the spectral type. For this reason, when the "Henry Draper Catalogue" gives a photometric magnitude to two decimals, greater accuracy is obtained in deriving the photographic magnitude from the visual by applying the colour index than by using a rough photographic magnitude. Some examples of this are given, and it is pointed out that in the "Henry Draper Catalogue" the error of the photographic magnitude for some of the bright stars is quite serious. It is suggested that there must be many stars within a distance of 10 parsecs for which the determination of absolute magnitude is rendered erroneous more by error in apparent magnitude than in parallax, and the conclusion is that a programme for determining the magnitudes of stars on parallax lists should be initiated.

THE MEDICAL RESEARCH COUNCIL

REPORT FOR 1948–50

THE successive reports of the Medical Research Council have always been welcome and valuable contributions to literature on the planning and progress of medical research. They have, as the Council's programme has grown and expanded, directed our minds through a maze of problems the inter-relations and complexities of which increase as the work of teams and individual workers extends and deepens our knowledge. It is not surprising that those who write these reports are faced with the problem of how to present the mass of material that nowadays is available and that changes in the form of the report have been adopted. These changes are apparent in the Council's latest account of its activities, "Report of the Medical Research Council for the Years 1948–50"*.

This valuable document records the Council's work since its war-time short-term researches came to an end. During the Second World War the Council had found that studies of practical problems generally led to valuable solutions, provided that substantial fundamental knowledge was already available; but that lack of sufficient basic knowledge limited and delayed the help that could be given. The Council has therefore wisely decided to apportion its resources between the search for basic knowledge and the study of practical problems which need to be solved at the present time.

Not all the researches in progress are mentioned in this report. Instead, a series of essays is given on the general trends of the work in progress, with summaries of the results, together with lists of the specific problems under investigation in each of the Council's many departments. The report also gives the personnel of each of these departments and—a valuable innovation—references, in a single list, to the papers published by members of the Council's staff. The publication is therefore a general account of the Council's work which summarizes, in effect, the present state of knowledge of each of the subjects considered, together with a valuable bibliography by means of which particular aspects of all this work can be followed up. Many will prefer this type of report to preceding ones in which the work of the separate departments has been given in greater detail.

The breadth of the Council's programme is indicated by the headings under which its work is epitomized. These are: chemotherapy and antibiotics, tuberculosis, virus diseases, *Q* fever, cortisone and adrenocorticotrophic hormone, methonium compounds, biological standardization, biochemical research, biological aspects of atomic physics, cancer research, blood groups and blood transfusion, tropical medicine, occupational health and undernutrition. From the summaries of work given under each of these headings, one can gain a valuable conception of the modern status of knowledge in each of these important fields. Separate reports dealing with the work done in some of them have already been published. An outstanding example is the remarkable publication entitled "Studies of Undernutrition, Wuppertal, 1946–9"*, which records the investigations made by the members of the Department of Experimental Medicine, University of Cambridge, and associated workers, on part of the population of Wuppertal and on German prisoners-of-war repatriated from the U.S.S.R. No one who is interested in this general matter of undernutrition, whether his interest be medical, sociological or political, can afford to miss this contribution to the problem. One wonders, while reading some parts of the report, especially the section that deals with emotional and behavioural reactions, how widely some of the symptoms described could be discovered in the United Kingdom at the present time.

This, however, is only one of the many special reports and memoranda issued by the Medical Research Council, all of which are evidence of the great services of its former secretary, Sir Edward Mellanby, whose retirement in 1949 was so universally regretted. In the report of the Council for 1948–50 there is a just tribute to his work and also to his personal research. Fortunately, neither his great experience and personal research abilities, nor those of Lady Mellanby, are lost to the Council, for Sir Edward remains as the director of the Council's Nutrition Building and Lady Mellanby is also working there.

To Sir Harold Himsworth, who succeeds to the secretary's duties and opportunities, Sir Edward leaves an organization of which the vigour and breadth of outlook are unrivalled. In it the spirit of its first secretary, Sir Walter Fletcher, still lives to inspire and encourage every member of the staff and to challenge succeeding secretaries to excel an achievement which owed much to Sir Walter's rare personality and outstanding gifts. In these days, when the Council's work has grown so much, it may be difficult for any man to keep the personal contacts with each member of the staff which were a feature of Fletcher's regime; but the same spirit will be there, the same drive for human health and the same underlying concern for the welfare of mankind.

G. LAPAGE

* Committee of the Privy Council for Medical Research. Report of the Medical Research Council for the Years 1948–1950. (Cmd. 8387.) Pp. iv+247. (London: H.M.S.O., 1951.) 6*s.* 6*d.* net.

* Medical Research Council. Special Report Series No. 275: Studies of Undernutrition, Wuppertal, 1946–49. Pp. iv+404+62 plates. (London: H.M.S.O., 1951.) 12*s.* 6*d.* net.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Dirac's New Electrodynamics

About twenty five years ago, W. Gordon[1], O. Klein[2] and I[3] shared in establishing a consistent set of field equations for a charge scalar ψ and the electromagnetic 4-potential A_k. To disencumber the formulæ, we take $c = 1$ and take the A^k to mean the ordinary potentials multiplied by $2\pi e/h$. Then the real Lagrangian density we used reads:

$$\tfrac{1}{4}F^{kl}F_{kl} + \tfrac{1}{2}(\psi_{,\underline{k}} - iA^k\psi)\,(\psi^*_{,k} + iA_k\psi^*) - \tfrac{1}{2}m^2\psi\psi^*, \quad (1)$$

with

$$F_{kl} = A_{k,l} - A_{l,k}. \quad (2)$$

The asterisk means the complex conjugate, a comma ordinary differentiation, underlining the subsequent raising of the subscript; the metric is $(-1, -1, -1, 1)$; m is the reciprocal Compton wave-length of 'the particle'; ψ and A_k have the dimension reciprocal length; the allotment of indices is the customary ($F_{.4} = E_x$, etc.), as opposed to the rational. From (1) and (2) one obtains the Euler equations:

$$\left(\frac{\partial}{\partial \underline{x_k}} - iA^k\right)\left(\frac{\partial}{\partial x_k} - iA_k\right)\psi = -m^2\psi \quad (3)$$

$$F^l{}_{k,l} = -j_k \quad (4)$$

with the 4-current

$$j_k = -\frac{i}{2}(\psi^*\psi_{,k} - \psi\psi^*{}_{,k}) - A_k\psi\psi^*, \quad (5)$$

for which the equation of continuity follows from (4) and independently from (3).

It seems to have remained unnoticed at the time and, so I believe, ever since, that simplification is obtained by a change of gauge. We put the real quantities:

$$A_k + \left(\frac{i}{2}\log\frac{\psi}{\psi^*}\right)_{,k} = \bar{A}_k \quad (6)$$

$$\psi\exp\left(-\tfrac{1}{2}\log\frac{\psi}{\psi^*}\right) = \sqrt{\psi\psi^*} = \varphi. \quad (7)$$

Then the (unchanged) j_k becomes

$$j_k = -\bar{A}_k\varphi^2, \quad (8)$$

while (3) splits openly into real and imaginary parts. The latter re-asserts that the vector (8) has vanishing divergence; the former reads

$$\frac{\partial}{\partial x_k}\frac{\partial}{\partial \underline{x_k}}\varphi = (\bar{A}_l\bar{A}^k - m^2)\varphi. \quad (9)$$

That the wave function of (3) can be made real by a change of gauge is but a truism, though it contradicts the widespread belief about 'charged' fields requiring complex representation. It is equally a truism that the bracket in (5) then vanishes, so that (5) turns into (8). But it is interesting that with (8) the equations (4) become those of Dirac's[4] recently proposed theory, the potential becoming proportional to the current.

Dirac's fifth field variable λ is, in the present setting, the square of the real amplitude φ. In a wave phenomenon the *rays*—corresponding to particle paths—are not sharply defined. The concept is based on the assumption that the wave amplitude varies comparatively slowly. The better this holds the sharper is the definition of rays, breaking down entirely when the assumption fails. It is peculiar to our case that the rapidly varying phase, with which the slowly varying amplitude is usually contrasted, is abolished. The only length available for comparison is m^{-1}. If φ does not vary appreciably at such range, then from (9),

$$\bar{A}_k\bar{A}^k - m^2 = 0 \quad (10)$$

holds approximately. This is Dirac's fifth field equation, from which, as he has shown, follows immediately that the vector lines of A_k are *paths* in the field F_{kl} that is described by (2); from (8) the same holds for the vector lines of j_k, which does not depend on the gauge. One is, I think, entitled to say that the stream lines are *rays* of the wave motion ψ as far as such can be spoken of at all. But one must keep in mind that a detailed description of the wave has meaning only with respect to a fixed gauge. By changing the gauge you may turn the wave-(hyper-) surfaces into whatever you please.

There is a handsome symmetry between the equations (4), with (8), and the equation (9). Their left-hand sides exhibit with respect to $\bar{A}_k$ and φ the completest analogy possible for a vector and a scalar, the operators being Div Rot and Div Grad, respectively. On the right, the quadratic invariant of the *other* quantity occupies, one may say, the position of an eigenvalue parameter in the otherwise linear equations. I venture to surmise that we are actually facing an eigenvalue problem. If so, it is mathematically much more involved than those we are accustomed to. Any charge-free Maxwellian field, by the way, satisfies our equations. One is interested in what happens when (3) is replaced by Dirac's wave equation of 1927, or other first-order equations. This and the bearing on Dirac's 1951 theory will be discussed more fully elsewhere.

I wish to thank Dr. Frank Roesler, scholar of the Institute, for illuminating discussion.

Erwin Schrödinger
Dublin Institute for Advanced Studies,
64–65 Merrion Square,
Dublin.
Jan. 25.

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Surface of Finely-Ground Silica

The existence of a highly soluble surface layer on quartz particles, foreshadowed by the results of Briscoe *et al.*[1], and of King[2], has been demonstrated in our laboratory, and the properties of the layer studied in considerable detail[3]. All siliceous dusts examined possessed initially a high-solubility layer which is apparently not discrete, but blends smoothly into the less soluble core. It is removed by various solvents, a borate buffer (*p*H 7·5) being principally studied; and it is dispersed by this buffer mainly in the form of somewhat flocculent colloidal silica, the less soluble core afterwards yielding, more slowly, clear solutions of silica. In view of the importance widely attached to the 'solubility theory' in studies on silicosis, it is clearly of interest to determine whether the high-solubility layer on inhaled siliceous

dusts plays any significant physiological part; and experiments on this problem have been initiated.

It has further been found that the initial high solubility can be at least in part restored to siliceous dusts from which the surface layer has been removed by solvents, by means of various after-treatments[4], though it does not follow that these all regenerate surface layers identical with each other, or with that originally present. Some of these methods are still under investigation; the most clearly defined so far is simple polishing of the solvent-treated dust by controlled agitation with abrasive powders[5]. This regeneration was shown by dusts prepared not only from natural crystalline quartz but also from commercial fused silica. We are not as yet prepared to define completely the physicochemical nature of this regenerated layer; but it appears to be closely associated with the classical Beilby layer on polished solids[6], and the two may possibly be identical. The evidence suggests that there exists on powdered quartz particles a vitreous skin, produced by surface-flow during grinding, and blending *via* a transitional layer into the truly crystalline core. It is less easy to apply this concept of a vitreous layer to dusts prepared from fused silica, which is itself nominally amorphous, unless on the not unlikely assumption that the core possesses some measure of organized structure—for example, a vestigial cryptocrystalline condition, or random crystallites of cristobalite of the type discussed by Warren and Biscoe[7]—which differentiates it from the high-solubility layer.

Since differential thermal analysis, as applied to the estimation of quartz, is dependent upon the specific $\alpha \rightleftharpoons \beta$ quartz transition at 575° C., and since any very finely ground silica dust should, on the above evidence, contain a considerable proportion of surface material which would not be expected to show this transition, caution appears necessary in applying this method to such a powder. The relationship between particle-size and measured thermal effect does not seem to have been fully investigated hitherto; and Roberts[8], in advocating differential thermal analysis for dust analysis, made the reservation that the independence of these factors remained to be proved. Some of our recent results[9] for a pure rock crystal confirm the view that the accuracy of the method falls off markedly as particle-size diminishes:

Period of grinding (hr.)	Average particle-size (μ)*	Quartz (per cent by diff. thermal analysis)
0	250	100·0
2	2·4	67·3
4	2·2	65·5
7	1·9	62·5
17	1·3	49·5

* Calculated from specific surface, determined by air-permeability.

That the above results are actually due to the presence of a layer of modified silica not estimated by differential thermal analysis, rather than to small particle-size *per se*, is shown by estimation of quartz in dusts, by the same method, before and after removing the high-solubility layer by etching with hydrofluoric acid:

	Rock crystal (*c.* 2·4 μ)	Lochaline sand (*c.* 5–10 μ)
Before etching	67·3 per cent quartz	88 per cent quartz
After etching	100 " " "	100 " " "

Our results by the method of differential thermal analysis have led us to the further conclusion that, after a short period of grinding (not accurately measured, but certainly less than an hour), the disturbed layer has reached a fairly constant maximum thickness, not significantly increased by subsequent grinding (up to 17 hr.) even though further size-reduction may thereby be achieved. If the high-solubility layer blends smoothly into the core, its 'thickness' has no precise meaning; but, on the over-simplified assumption of a spherical crystalline core within a uniform shell of modified silica, a rough first approximation may be reached by calculations based on (*a*) the dispersal of the surface layer by borate buffer[3], (*b*) the reduction in density shown by quartz on grinding[5], or (*c*) the proportion of silica not detected by differential thermal analysis. The results are, respectively, (*a*) *c.* 0·02–0·03 μ, (*b*) *c.* 0·03–0·05 μ, and (*c*) *c.* 0·11–0·15 μ.

A fuller account of the above work, which is sponsored by the National Coal Board (Scottish Division), will be published elsewhere.

P. B. Dempster
P. D. Ritchie

Department of Technical Chemistry,
Royal Technical College,
Glasgow, C.1.
Nov. 9.

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In the course of silicosis research, a photographic-densitometric X-ray diffraction technique was developed for quantitative determinations of quartz, using magnesium oxide as internal standard, and recording line intensities in the range of 1·18–1·22 kX. With this technique it was found that carefully graded samples of quartz of less than 2 microns diameter gave lower intensities than larger fractions, although the fine samples showed only very slight indications of line broadening, and those only in the back-reflexion region. Numerical examples are given in Table 1, where the quartz ratings are expressed as percentages, taking the values for ungraded quartz from Madagascar as 100 per cent.

Previous work at the Mellon Institute[1] with Geiger counter equipment showed that the intensities of X-ray diffraction lines of quartz powders were low

Table 1. X-Ray Estimates of Quartz in Sized Fractions

Quartz samples	Size in microns	Quartz rating
Madagascar	ungraded	100
"	< 5	97
"	< 2	66
"	< 1	58
Glass sand	< 5	84
"	< 2	78
"	0·5–1	73
"	< 1	68

on account of extinction and other factors if the samples were too coarse. However, the intensities increased with decreasing size, reaching a maximum with a size less than 5 microns, which was the finest sample tested.

Physical and chemical evidence exists suggesting that in quartz single crystals, after grinding or lapping, and in quartz powders after drilling or grinding, an imperfectly crystalline or amorphous layer surrounds a more perfectly crystalline core. E. J. Armstrong[2] has summarized the information on single crystals. In the paper referred to above[1], the same suggestion is made for powder, and in the course of his work on repeated extractions of quartz E. J. King[3] came to the same conclusion. He states, "All sizes of quartz particles [less than 1, 1–2, 2–5 microns] behaved as if a soluble fraction of silica was being leached from their surfaces, leaving a relatively insoluble residue, or core, which seems to be resistant to the dissolving action of water".

In order to test the idea that in our samples an outer, possibly amorphous, layer existed, they were subjected to a severe etching with hydrofluoric acid, and the quartz content of the residues was again determined. The residues showed higher quartz ratings, as demonstrated in Table 2. If the assumption is made that the outer layer is entirely amorphous and does not absorb X-rays, it is possible to estimate the thickness of this layer. The figures obtained are shown in Table 2.

Table 2. X-Ray Estimates of Quartz Samples Before and After Etching with Hydrofluoric Acid

Samples	Size (microns)	Quartz rating		Thickness of outer layer (microns)
		Before etching	After etching	
Belgian glass	0·5–1	73	94	0·03
Sand	< 1	68	95	0·03

Similar estimates of the thickness of the layer made from King's results, assuming the amorphous layer only to be soluble, also give values of the order of 0·03 micron.

The effect described will lead to analytical error which becomes more severe as smaller particles of quartz are analysed. The detailed relations between silica solubility and quartz analyses by X-ray diffraction, chemical methods and differential thermal analysis are now being determined.

It is not possible at this stage to say what bearing these observations have on pathological effects of quartz; but animal experiments are in progress in E. J. King's laboratory using graded samples with and without this outer layer.

We acknowledge gratefully help from Drs. Klug and Alexander, of the Mellon Institute, who confirmed some of our findings, gave additional information on line shapes and background intensities, and also suggested the existence of an amorphous surface layer; and similar help from Dr. de Wolff, of Delft.

G. Nagelschmidt
R. L. Gordon
O. G. Griffin

Safety in Mines Research Establishment,
Portobello Street,
Sheffield.
Nov. 9.

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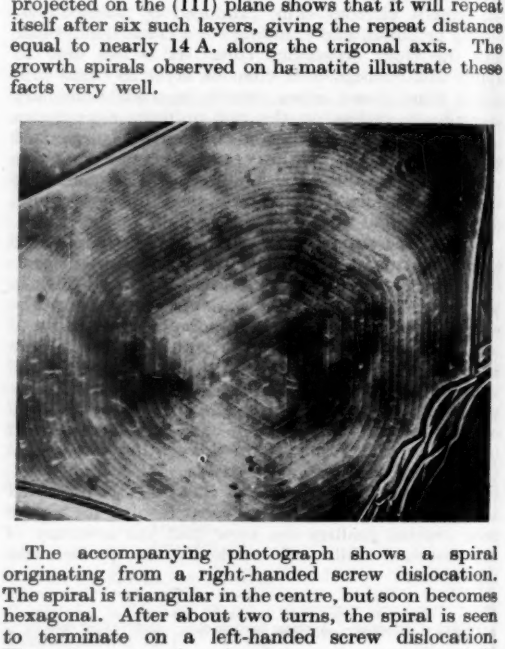
Growth Spirals on Hæmatite (Fe_2O_3) Crystals

The observation of 'growth spirals' on silicon carbide (Si—C) crystals was reported by me recently[1]. It was shown that the observations are in accordance with the theory of crystal growth put forward by Burton, Cabrera and Frank[2].

Similar observation of growth spirals on hæmatite (Fe_2O_3) crystals are now reported. Hæmatite[3], which is isomorphic with corundum (Al_2O_3), may be referred to the rhombohedral axes making an angle of 85° 42′ with each other, or to hexagonal axes with $a : c = 1 : 1{\cdot}36$. X-ray measurements show that the oxygen atoms are arranged in approximately hexagonal close-packing. Between two successive layers of oxygen atoms there are positions for cations. The distance between successive layers of oxygen atoms is nearly 2·3 A. along the trigonal axis, which is perpendicular to the (111) plane. The structure when projected on the (111) plane shows that it will repeat itself after six such layers, giving the repeat distance equal to nearly 14 A. along the trigonal axis. The growth spirals observed on hæmatite illustrate these facts very well.



The accompanying photograph shows a spiral originating from a right-handed screw dislocation. The spiral is triangular in the centre, but soon becomes hexagonal. After about two turns, the spiral is seen to terminate on a left-handed screw dislocation. Thereafter successive closed loops are generated in accordance with theory.

The measurement of step height between successive arms of the spiral, by the application of multiple-beam interference fringes[4], shows it to be nearly 16 ± 3 A. This, within experimental errors, confirms the X-ray measurements.

Besides this elementary type of spiral, several other more-complicated growth patterns have also been observed, some of which give interesting comparison with similar observations on silicon carbide crystals. One feature seen clearly in the present photograph is that, unlike silicon carbide, the point of emergence of screw dislocation on the crystal surface is not marked by a hole, showing that in this case the core is not hollow.

A detailed account of this work is being communicated elsewhere.

I wish to express my thanks to Prof. S. Tolansky for his interest and suggesting that hæmatite be

examined. I am grateful to the authorities of the British Museum (Mineralogical Department) for the loan of the crystals, and to the British Council for a scholarship.

AJIT RAM VERMA

Royal Holloway College,
(University of London),
Englefield Green,
Surrey.
Dec. 31.

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Interference Microscopy and Mass Determination

WE are interested to find that Dr. R. Barer, in his letter dated October 20, 1951[1], has evolved the method of mass determination in cells by interferometry. We have already described what is apparently this method at a meeting of the Society for Cell Biology in September 1951[2]; but, as our conclusions may not be generally known, we would like to state them briefly here.

Cell interferometry provides a new method of measuring growth, and we have been trying the method with the view of obtaining, in living cells, measurements of total substance (other than water) so as to correlate these with measurements[3,4] of total quantity of ultra-violet absorbing substance. In contrast to ultra-violet microscopy, cell interferometry will not injure living cells, and hence a quantitative record may be obtained of the change of substance in one cell during a long period of time, and during intracellular changes.

The usual formula, for solutions, connecting quantity of dissolved substance with optical path-length applies also for concentrated gels and dry substances, and may be expressed in the form

$$M = \frac{\varphi}{\chi},$$

where M is the mass of substance per unit area, φ is the optical retardation produced by the substance. χ for solutions is 100 α, where α is the specific refractive increment. χ for a dry substance is $(\mu_1 - \mu_2)/\rho$, where μ_1 is the refractive index of the substance, μ_2 is the refractive index of the immersion medium, ρ is the density of the substance.

As Barer has pointed out, values of α for solutions of proteins and deoxyribose nucleic acid are $\sim 0{\cdot}0019$ ($\chi = 0{\cdot}19$). The figures in the accompanying table show, however, that for other cell constituents χ does not vary much, and hence one may expect cell interferometry to give approximate dry weights of cells and cell constituents, *independent of composition*. In fact, the very non-specificity of light refraction makes cell interferometry a useful complement to specific cytochemical methods. Large proportions of lipoid in protein, even fats themselves, and carbohydrates will seldom introduce an error which is likely to be greater than that involved in the optical measurements. Ovalbumin and tobacco mosaic virus contain, respectively, small and large proportions of aromatic amino-acids, but the value of χ is not significantly different. Salts sometimes give markedly different values of χ, but this will seldom introduce error as the concentrations are low, and the effect is likely to be cancelled out by similar concentrations in the isotonic medium in which the cells are immersed.

Compound	Physical state	Density	Refractive index	χ
β-Lipoprotein[5] (75% lipid)	dil. sol.			0·17
Fats[6]	Nat.	0·93 av.	1·46 av.	0·14 av.
Sucrose[6]	2% sol.	1·006	1·3359	0·141
Sucrose[6]	Cryst.	1·588	1·558	0·141
Starch[6]	Solid	1·50	1·53	0·133
Ovalbumin[7]	1·61% sol.			0·187
Ovalbumin[7]	6·45% sol.			0·188
Tobacco mosaic virus[8]	dil. sol.			0·17
Tobacco mosaic virus	dry solid	1·335 av.[9]	1·534[10]	0·151
Gelatin[6]	dry solid	1·27	1·525 av.	0·151
Sodium chloride[6]	5·25% sol.	1·035	$1{\cdot}34_8$	0·163
Sodium chloride[6]	Cryst.	2·165	1·544	$0{\cdot}097_8$
Potassium chloride[7]	10% sol.	1·07	1·3449	0·115
Potassium chloride[6]	Cryst.	1·984	1·490	0·079
Calcium chloride[6]	17% sol.	1·143	1·374	0·21
Calcium chloride[7]	Cryst.	2·512	1·52	0·075
Yeast nucleic acid[11]	Approx. 2% sol.			0·168

The second important aspect of the method is that it gives dry weights *independent of concentration*. Even in cells where much of the nucleus and cytoplasm contains as little as 10 per cent or less dry weight, the nucleoli may contain $\sim$ 70 per cent dry weight. If the substances involved obeyed the Lorenz–Lorentz relation[6], χ would increase somewhat as the concentration increased. However, such approximate data for dry proteins as exist indicate that χ decreases instead of increasing with concentration.

Inhomogeneous distribution of substance, and resulting light scatter, diffraction, etc., will introduce errors in cell interferometry in much the same way as in microspectrography, and an analysis of these errors is in progress. However, from what has been said above, a general rule of some importance to microscopists emerges. In cells, differences of composition (with dry weight per unit area remaining constant), such as difference in proportion of nucleic acid and protein, will not produce large percentage differences of optical path-length. Hence, interference microscope and phase-contrast pictures of cells are generally pictures of dry-weight variation.

H. G. DAVIES
M. H. F. WILKINS

Medical Research Council
Biophysics Research Unit,
King's College,
London, W.C.2.

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Mercury Hydride Ions in the Mass Spectrometer

Mercury hydride has been studied in optical spectroscopy; but little has been published on the formation of hydrides in the mass spectrometer.

The mass spectrometer used for investigating this field is the sector type[1], 60° single focusing with 6-in. radius of curvature, made by the General Electric Company. The pressures were measured on a *VG1A* ion gauge at the tube exit. The gauge was calibrated with argon so the hydrogen pressures were actually higher, and in the ionizing region higher by a factor of 10 or more, than the ion gauge pressure recorded.

To study this effect for mercury–hydrogen mixtures, the two gases were held in a sample-system manifold with a leak leading to the spectrometer. Liquid mercury in the manifold at 30° C. furnished saturated mercury vapour at 2·8 microns pressure. Hydrogen, purified by diffusion through hot palladium, was then added, at varying partial pressures.

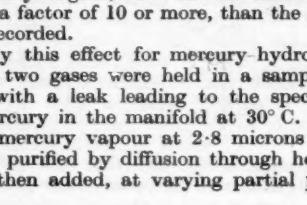

Fig. 1. Mercury hydride ion in excess hydrogen

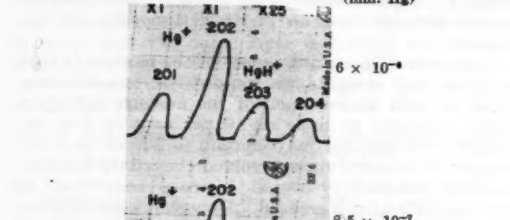

Fig. 2. Loss of resolution at high hydrogen pressure

Spectra were recorded using magnetic scan at 1,500 V. accelerating, 70 V. ionizing, potential.

The hydride ions, $^{2\cdot3}HgH^+$ and $^{2\cdot4}HgH^+$, are shown as peaks in Figs. 1 and 2. The conditions for the mass spectra of Fig. 1 are given in the accompanying table.

H_2 (microns on leak, McLeod gauge)	Ion gauge pressure (mm.)	$^{203}HgH^+$ Peak 203 intensity (relative to ^{202}Hg = 100)
358	$6{\cdot}0 \times 10^{-6}$	0·155
101	$2{\cdot}0 \times 10^{-6}$	0·078
40	$8{\cdot}5 \times 10^{-7}$	0·039
11	$4{\cdot}0 \times 10^{-7}$	0·022
0·01	$1{\cdot}6 \times 10^{-7}$	less than 0·002

The intensity of peak 203, $^{2\cdot3}HgH^+$, is proportional to the square root of the hydrogen pressure. This should follow for the reaction: $2Hg + H_2 = 2HgH$, where the mercury partial pressure is held constant, and the hydrogen pressure is varied.

In Fig. 2, very high hydrogen pressures with the mercury lead to initial loss of resolution as shown in the series of spectra with decreasing hydrogen pressure. These, all at the same amplification, show $^{2\cdot4}HgH^+$ as well as $^{2\cdot3}HgH^+$.

Francis J. Norton

Research Laboratory,
General Electric Company,
Schenectady, N.Y.
Oct. 2.

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Production of the Joshi Effect under β- and γ-Rays

Examination of the literature having shown absence of information on the Joshi effect under radioactive emanations, a detailed investigation was made employing, in the first instance, a β-ray capsule with negligible γ-ray activity. Siemens ozonizer type tubes charged with various vapours and gases and excited by commercial-frequency potentials of kilovolts were used. In agreement with results obtained with visible[1] and ultra-violet[2] radiation and with X-rays[3–6], and employing especially organic vapours, an exposure to β-rays caused an instantaneous and reversible positive effect $+ \Delta i$ at relatively low voltage; with slight increase of voltage, $+ \Delta i$ diminished sharply; and finally changed over to $- \Delta i$ ab.ve V_m, the threshold for a 'self-maintained' discharge. Thus, for example, *cyclo*hexane vapour showed under β-rays about 150 per cent positive Joshi effect at 4 kV.; + 9·5 per cent and − 5·8 per cent at 6 and 8 kV. respectively.

Simultaneously with the production of $+ \Delta i$, high-frequency pulses appeared in the current structure, lasting only during exposure to β-rays, when observed with a cathode ray oscillograph. $- \Delta i$ obtained at higher voltages corresponded to an instantaneous and reversible decrease of the amplitude of the high-frequency pulses. In an electronegative gas, only $- \Delta i$ was detected: it decreased with the overvoltage $V - V_m$; thus, for example, with chlorine at 110 mm. mercury pressure, $- \Delta i$ was 11·4 and 2·4 per cent at 4 kV. and 20 kV. respectively.

The action of a Geiger–Müller counter can be usefully compared with the mechanism of an ozonizer

discharge[4]. We suggest tentatively that the potential within which $+\Delta i$ occurs corresponds to the proportional or/and Geiger region. In extending their ranges and as self-quenchers, the role of organic vapours is well known[5]. The ozonizer filled, for example, with *cyclo*hexane vapour was tested for sensitivity to background counts. It begins to 'count' near the potential where $+\Delta i$ sets in. The chief limitation of the ozonizer is that the plateau is not flat. The rareness of $+\Delta i$ in electronegative gases may be ascribed partly to the electron attachment, causing a reduction of the plateau. The recent observation[9] of a large and reversible $+\Delta i$ in an argon–methane counter in the plateau region on irradiation in the visible region supports this analogy.

Essentially similar results are observed under γ-rays; and a like investigation using α-rays is in progress. We wish to express our thanks to Prof. S. S. Joshi, Banaras, Prof. V. N. Thatte and Dr. B. V. Thosar, Nagpur, for guidance and valuable help.

V. G. Bhide
M. R. Bhiday
G. V. Asolkar

Department of Physics,
College of Science,
Nagpur.
Oct. 9.

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Two Band Systems of Tungsten Oxide

The spectrum of a high-tension D.C. arc between spectrographically pure tungsten electrodes was photographed in the near infra-red, the visible and the ultra-violet regions using the Steinheil 3-prism-spectrograph with a camera focus of 1,600 mm. Though the spectrograms were largely covered with continuous background, a number of red degraded bands could be recognized and were measured on the Abbe comparator.

As neither sequences nor progressions were readily recognizable, recourse was had to extrapolation of the value of ω_e'' of tungsten oxide from the values of the oxides of neighbouring elements in the periodic table as shown below.

VO 1,012·7		CrO 898·8	
	AsO 967·4		SeO 907·1
CbO 1,002·9		MoO —	
	SbO 817·2		TeO 796·0
TaO 1,161·6		WO 1,060	

Starting with the intense band heads ν 20,799·9 and ν 22,417·8 as (0,0) bands of two different systems and using the value 1,060 obtained above as the probable value of ω_e'', it was possible to construct the two accompanying ($v'v''$) schemes.

Two Systems of Tungsten Oxide

(1)

v' \ v''	0	1,054·9	1	2
0	20,799·9(6) 979·4		19,745·0(3) 981·9	—
1	21,779·3(4) 966·8		20,726·9(3) 960·8	19,679·5(2)
2	22,746·1(5)		21,687·7(4) 961·1	—
3			22,648·8(1)	—

(2)

v' \ v''	0	1057·5	1
0	22,417·8(5) 988·3		
1	23,406·1(4)		22,348·6(2)
2			23,336·4(3)
3			24,323·9(6)

A third system with ν 21,227·3 and ν 22,217·8 as the (0,0) and (1,0) bands appear possible; but more cannot be said at this stage.

A. Gatterer
S. G. Krishnamurty

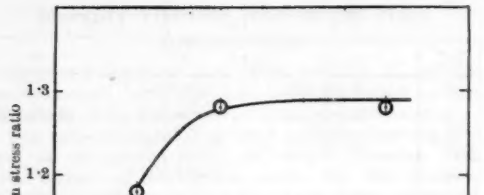
Laboratorio Astrofisico,
Specola Vaticana,
Vatican City.
Nov. 9.

Effect of Surface Films on the Twinning of Metal Crystals

In a recent communication, Gilman[1] reports that an electrodeposited layer of copper raises the stress necessary to cause twinning in single crystals of zinc. This result is in accord with a series of observations, to be published shortly, by Dr. S. M. Gumbrell and myself, on the effect of surface condition on the twinning behaviour of cadmium crystals.

Long single crystals, 1 mm. in diameter, were grown by the method of Andrade and Roscoe[2] and cut into several lengths, which were given different surface treatments. The specimens were then tested in tension in a rigid frame apparatus in which the strain was brought about by means of a micrometer screw movement. A Polanyi beam was used for measuring the stress with a high degree of sensitivity. Stress–strain curves were obtained, and the onset of twinning, being accompanied by a sudden drop in stress, was readily detected.

It was found that specimens in which the angle ψ between the tension axis and the basal plane was less than about 3° were not deformed by slip to any measurable extent before twinning occurred. Where ψ was greater than this, appreciable glide preceded twinning. Reproducibility of twinning behaviour was remarkably good in those cases where no slip preceded twinning, but results for specimens which showed appreciable glide were not so consistent. The accompanying graph shows the effect of surface oxidation produced by heating the specimens at 240° C. in oxygen at 50 cm. pressure for different lengths of time, the angle ψ being less than 3° in all cases. By twin stress ratio is meant the ratio of the stress necessary to cause twinning in the oxidized specimen to that necessary for the untreated length of the same crystal. Each point represents the mean of a number of observations. The actual thickness of the oxide layer was not measured; but there is clearly an increase of twin stress with thickness of oxide coat, approaching a limit of about 30 per cent.



Similar results were obtained for specimens oxidized under different conditions, and with others coated with an electrolytically deposited hydroxide layer. In the latter case the twin stress increased by up to 50 per cent. Removal of the surface layer reduced the twin stress, and there was no evidence of permanent modification due to the treatments given.

Two samples of cadmium were examined, spectroscopically pure (99·999 per cent cadmium) and a less pure sample (99·967 per cent cadmium). The effects were similar in the two cases.

These observations form part of a wider investigation into the process of twinning, in which evidence has been obtained that the criterion for the onset of twinning is similar to that for slip, namely, the resolved shear stress on the twin plane in the twinning direction must attain a critical value.

If σ_S is the resolved shear stress necessary to produce slip and σ_T the resolved shear stress for twinning, a specimen will twin rather than slip when its orientation is such that the actual ratio (T/S) of the resolved shear stress on the twin plane to that on the slip plane is greater than σ_T/σ_S. This is true where ψ is small. Where ψ is large enough for slip to occur, in a normal tensile test the orientation of the crystal changes in such a manner that T/S increases and twinning occurs at that stage where T/S reaches σ_T/σ_S.

The value of σ_T/σ_S thus defines the orientation at which twinning occurs. σ_T as well as σ_S was found to vary with glide, and σ_T is affected to a different degree from σ_S by the presence of a surface layer. As a consequence, for a specimen of given initial orientation, the orientation necessary for T/S to reach σ_T/σ_S was found to be different when the surface was treated from that when untreated. Thus, not only the stress necessary to produce twinning, but also the extent to which a specimen slips before twinning, is modified by a surface layer.

The relationships are somewhat complex, leading in some cases to a reduction in slip before twinning and in others to an increase, according to the orientation of the crystal.

Ronald King

Davy Faraday Research Laboratory,
Royal Institution of Great Britain,
21 Albemarle Street,
London, W.1.
Jan. 30.

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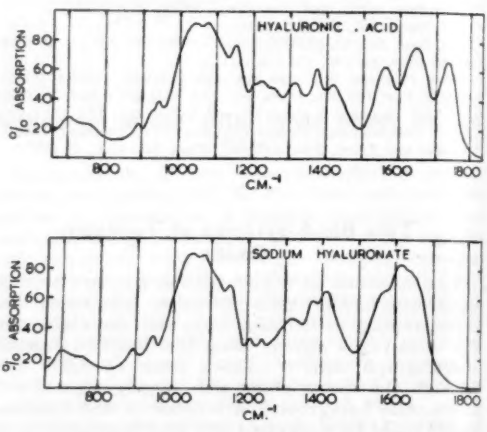
Evidence from Infra-Red Spectroscopy for the Composition of Certain Polysaccharides

Previous infra-red spectral measurements of polysaccharides have been mainly concerned with cellulose and its derivatives[1–6]. Differences in hydrogen bonding in these materials have been deduced from differences in their spectra at 3 μ [4,6] and 6 μ [2], and the products of their oxidation have been investigated, the new bands produced being assigned to specific groups[1,4,5]. Chitin and the related chitosan and chitin nitrate have also been studied[7], and in this case evidence as to chain structure and inter-chain bonding has been obtained.

The present work has been concerned with chondroitin sulphuric acid from cartilage and hyaluronic acids from various sources; for these polysaccharides, the first problem is to determine their molecular composition, before proceeding to a more detailed examination of chain structure. The manner in which the former is being achieved can be seen from the accompanying figures, in which the spectrum of a sample of hyaluronic acid from human umbilical cord is shown for the acid and its sodium salt. The spectra were obtained on a Perkin–Elmer 12*C* spectrometer with rocksalt prism, using films prepared by casting from aqueous solution.



Hyaluronic acid is usually regarded as a polymer formed by approximately equimolar amounts of N-acetylglucosamine and glucuronic acid; but there is no conclusive evidence as to the exact ratio, the extent of acetylation of the amino groups, or the presence or absence of acetoxy groups. In the spectrum of the free acid, the band at 1,735 cm.$^{-1}$ is assigned to an un-ionized carboxyl group[8,9] and the pair of bands at 1,648 and 1,560 cm.$^{-1}$ to a monosubstituted amide[10]; from the relative intensities of these bands, variations of the ratio of acid to amide in different specimens have been deduced. In the spectrum of the sodium salt, the free carboxyl band has disappeared, and bands at 1,610 and 1,410 cm.$^{-1}$ characteristic of the carboxyl ion[8,9] appear. The upper band overlaps the two amide bands, but these have been separated graphically, and the exact frequencies of the bands obtained, namely, 1,648, 1,610 and 1,560 cm.$^{-1}$. The absence of any residual absorption maximum around 1,735 cm.$^{-1}$ shows that none of the hydroxyl groups is acetylated, since this would

result in absorption at 1,740 cm.$^{-1}$, the position characteristic of acetates[11].

Samples of chondroitin sulphuric acid and of sulphate-esterified hyaluronic acid have also been measured, and are characterized chiefly by very strong absorption with a broad maximum between 1,230 and 1,255 cm.$^{-1}$, assigned to the sulphate group as in sodium alkyl sulphates[6]. The absence of such absorption in sodium hyaluronate of human origin (the free acid has a band of moderate intensity at about this position, associated with the carboxyl group[6,8]) confirms other results for the absence of sulphur.

These observations indicate the methods by which we are applying infra-red spectroscopy to the problem of the determination of the composition of these polysaccharides, the molecular composition of which is not completely known. The detailed results obtained will be published elsewhere.

S. F. D. Orr
R. J. C. Harris

Chester Beatty Research Institute,
The Royal Cancer Hospital,
Fulham Road,
London, S.W.3.

B. Sylvén

Cancer Research Division,
Radiumhemmet,
Stockholm 60,
Sweden.

Nov. 9.

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Reduction of Triphenyltetrazolium Chloride by Plant Tissues and its Relation to Molybdenum Status

Triphenyltetrazolium chloride has been used recently for indicating enzymatic reducing systems in several tissues[1–5] under aerobic as well as anaerobic conditions, and many other similar applications have been reviewed by Smith[6]. We have found that sections of petioles or stems of tomato, cauliflower, swede, kale, clover and other plants are characteristically stained by reduction of solutions of triphenyltetrazolium chloride to the insoluble red formozan pigment. Staining is intense in phloem and strong in cambium and vascular parenchyma, and often in endodermis. It is weak in cortex and epidermis, and negligible or absent in xylem and semi-lignified tissues, for example, pericycle. In leaves the mesophyll stains less than the phloem and vascular parenchyma. Our results confirm closely those of Gall[7] (with bean stems) and others[3] unknown to us until this work was well advanced.

Reducing activity in cauliflower petioles is nil below *p*H 3·5 and increases rapidly as the *p*H is raised. Above *p*H 8·5 (approximately) glucose, ascorbic acid, —SH compounds, etc., react non-enzymatically[8]. The reducing activity of cauliflower petiole in phosphate buffers (*p*H 4·1–7·0) is destroyed after steaming and also by homogenizing (except in occasional unbroken vascular strands). In intact sections, some factor is bound to the tissues, since formozan is only precipitated in the solution after several hours but is deposited rapidly in the active tissues. Reduction is completely inhibited by *M*/100 azide and is strongly inhibited (decreasing order) by *M*/100 cyanide, contrary to findings of Roberts[9] for maize embryos, and by *M*/300 iodoacetate (*p*H 4·1–6·8). At high *p*H values these poisons do not inhibit, and their effects are, in fact, widely different in different tissues[1,2,5,8].

Tissues of plants grown without molybdenum possess only weak reducing activity compared with normal material. This phenomenon was repeatedly observed in cauliflower and tomato petioles and confirmed in swede, kale, lucerne, clovers, beans, potato (petiole and tuber) and others. It was also found by one of us (E. J. H.) that the reducing activity of *Aspergillus niger* mycelia similarly depended on molybdenum status. As with ascorbic acid[10], high levels of molybdenum do not further increase formozan production appreciably. During the progress of our work, Evans *et al.*[11] have reported that homogenates of molybdenum-deficient lucerne foliage had a decreased 'dehydrogenase' activity as indicated anaerobically with methylene blue. We have confirmed this effect in cauliflower petioles; but find it less marked than that obtained with triphenyltetrazolium chloride. Sections under a cover glass decolorize methylene blue most actively in cambium and vascular parenchyma, phloem becomes blue-green and other tissues remain blue.

The distribution of molybdenum (determined in plants grown with adequate molybdenum by staining sections with stannous chloride and thiocyanate), and of precipitated formozan are apparently identical. Confirmation of a similar distribution in deficient tissues was observed by assay with *A. niger*[14]. The localization of molybdenum in phloem and vascular parenchyma especially is interesting, since many mineral elements are considered to be translocated in xylem. Thus manganese located with tetramethyldiaminodiphenylmethane by one of us (E. J. H.) showed the highest concentrations in the xylem of tomato petioles, especially when high levels were given.

The effect of molybdenum on reducing activity is apparent in plants grown with nitrate, and also in those given ammonium nitrate, ammonium sulphate, ammonium citrate or urea, where the essential nature of molybdenum has now been shown[13,14], but with nitrite the differential effect is minimized. Nitrite also inhibits formozan production in sections and is possibly reduced even in competition with triphenyltetrazolium chloride, which itself presumably competes with the natural hydrogen acceptors.

Brodie and Gots[5] suggested that a diaphorase enzyme may be the true site of triphenyltetrazolium chloride reduction by yeast. This is of interest here, since the dehydrogenases known to be activated by metals require magnesium or manganese, both of which are present in our material in adequate amounts irrespective of molybdenum status. Molybdenum may thus be necessary for the participation of some other factor(s) at a later stage than a dehydrogenase *per se* inferred by Evans *et al.*[11]. The similar distribution of molybdenum and reducing

activity also raises the question whether the most reactive tissues are, in fact, the main sites of the particular metabolic activity for which molybdenum is an essential plant nutrient.

E. J. Hewitt
S. C. Agarwala

Long Ashton Research Station,
University of Bristol.
Nov. 5.

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Thiophosphates as Possible Intermediates in Phosphate Transfer

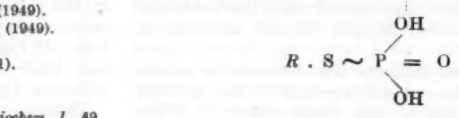
In general, enzymes concerned with the transfer of 'high-energy' phosphate depend for their activity on the presence of free thiol groups, and it has been suggested that the enzyme-substrate combinations of the phosphokinases may involve the formation of —SH—Mg— phosphate complexes[1]. The phosphatases, adenosine-triphosphatase[2] and hexose-diphosphatase[3], have also been shown to be sulphydryl enzymes.

In view of the possibility that the thiol groups of proteins, or of simpler compounds, may function in transacylating mechanisms through the formation of unstable (energy-rich ?) thioesters, it is of great interest to compare the stability of simple thiophosphates with other naturally occurring derivatives of phosphoric acid.

Various methods for the preparation of esters of thioalcohols and thiophenols with phosphoric and other acids have been described in the literature[4], and from the information available it appears that the thioesters exhibit considerable variation in stability. Salts of oxythiophosphoric acids have also been prepared[5]; but the free acids decompose spontaneously in solution owing to fission of the S—P bonds.

For preliminary use in the present investigation a simple alkyl-S-thiophosphoric acid was prepared as follows. Recently prepared sodium *n*-propylmercaptide (1 mol.) was mixed with freshly distilled phosphorus oxychloride (1·2 mol.) in light petroleum at 0°. Ice (2–3 mol.) in pyridine (2–3 mol.) was added, and after a short interval the mixture was diluted with ice-cold water and the aqueous layer was repeatedly extracted with light petroleum until free from the odour of mercaptan. The barium salt of *n*-propyl-S-thiophosphoric acid was precipitated by the addition of barium acetate and obtained free from inorganic phosphate by reprecipitation from solutions in ice-cold dilute acid. Solutions of the sodium salt of the thioester were prepared freshly as required from sodium sulphate and the barium salt.

The inorganic phosphate in a freshly prepared solution of known total phosphorus content was determined, before and after hydrolysis in *N* hydrochloric acid at 100° for seven minutes, by the methods of Fiske and SubbaRow and of Lowry and Lopez[6]. Hydrolysis to inorganic phosphate was complete in the seven minutes. These results suggest that some esters (I) of phosphoric acid with thiol compounds exhibit an instability comparable with that of the labile phosphate residues of adenosine triphosphate.



(I)

It is suggested that unstable thioesters of phosphoric acid may be formed in biological systems as intermediates in phosphate-transferring mechanisms. A similar suggestion has also been advanced by Lynen, Reichert and Rueff[7], who deduced that phosphorylation of coenzyme *A* by adenosine triphosphate may be a primary reaction in the formation of the active acetyl derivative.

The thiophosphate ester used in these experiments has not as yet been obtained completely pure, as all samples prepared so far have contained some pyrophosphate. It is considered unlikely, however, that the pyrophosphate impurity would influence the stability of the S—P bond under the above conditions of hydrolysis.

E. O'F. Walsh

Department of Physiology,
Royal Free Hospital School of Medicine,
London.
Nov. 26.

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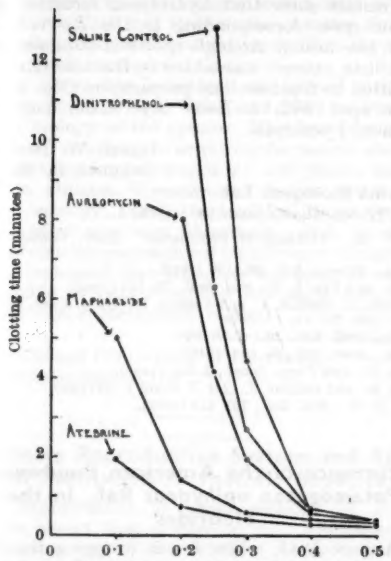
Action of Heparin

Observation of a rapid fall in 'inorganic phosphate' of heparinized whole blood and plasma led to study of the phosphate changes in shed blood. The effect of heparin on blood phosphate *in vivo* has been reported[1]. Further study of the effect of heparin *in vitro* led to the view that the action of heparin may be associated with phosphate uptake.

The effect of certain 'uncoupling' reagents is therefore reported. Dinitrophenol, dinitro-*o*-cresol, atebrine[2] and aureomycin[3] share this property. Aureomycin has already been reported to lower the concentration (*sic*) of heparin in plasma *in vitro* and *in vivo*[4]. All four reagents accelerate the clotting of normal human plasma, on recalcification or the addition of thrombin, with and without added heparin. Dinitrophenol is effective at 5×10^{-5} *M*, and the partial inhibition of the anti-thrombic action of heparin by it at 5×10^{-4} *M* is shown in the accompanying graph. Inhibition by atebrine is more marked. Dinitrophenol and atebrine reduce the simple clotting time of crude-fraction I-thrombin,



Thrombin clotting times, at 16° C. and pH 7·5, of human citrated plasma containing 0·25 units/ml. heparin; effect of 2×10^{-4} *M* dinitrophenol; 50 mgm. per cent aureomycin; 0·25 gm. per cent mapharside (*m*-amino *p*-hydroxyphenylarsinic acid); 5×10^{-4} *M* atebrine

but this requires more critical study[5]. Negative results have been obtained with azide, iodoacetate and *l*-thyroxine.

Attempts to demonstrate an inorganic phosphate requirement for the action of heparin have so far failed, but arsenite at 2×10^{-3} *M* is inhibitory. It seems possible, therefore, that the anti-thrombic action of heparin is mediated by a coupled phosphorylation.

JOHN GREEN

Department of Clinical Chemistry,
Royal Infirmary,
Aberdeen.
Nov. 3.

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Cortisone and *Plasmodium berghei* Infection in Mice

THERE is considerable clinical evidence to show that in persons infected with malaria various stimuli may precipitate an acute attack. These stimuli include surgical operations, the injection of vaccines, exposure to cold, and possibly, for persons who have not become acclimatized, ascent to high altitudes. There is also evidence, both clinical and experimental, to show that injections of cortisone increase the virulence of bacterial and virus infections. Trypanosome infections also, including Chagas's disease, are intensified in animals given cortisone[1,2].

In mice infected with *Plasmodium berghei*, cortisone appears to act in a similar manner. When mice are inoculated subcutaneously with 0·1 ml. of mouse blood, infected with *P. berghei*, and showing approximately 300 infected red blood cells per 1,000 red cells, parasites appear in very small numbers in the peripheral blood stream in about twenty-four hours and death occurs in nine to eleven days. In two experiments, twelve mice weighing 20 gm. were inoculated intramuscularly with 5 mgm. cortisone acetate; 30 min. later, these and twelve control mice were injected subcutaneously with 0·1 ml. of mouse blood in which counts showed that approximately 330 red cells per 1,000 were infected with parasites. The same dose of cortisone was repeated six hours after infection with the parasites, while the mice not receiving cortisone were given 0·1 ml. of physiological saline intramuscularly. The same doses of cortisone and physiological saline were given intramuscularly four days later to the two sets of mice. Normal mice given cortisone in this manner have remained healthy. Smears were made of blood from the tails of cortisone-treated and saline-treated mice six hours after infection and thereafter morning and evening until death. The smears were stained by Giemsa's method and 1,000 red cells were counted from each film, a note being made of the number of red cells infected with *P. berghei*.

In the cortisone-treated mice, it was noticeable that parasitized red cells were already present in the peripheral blood stream in the proportion of 10–16 per 1,000 at six hours after infection, whereas control mice failed to show any parasites in the peripheral blood stream at this period. At twenty-four hours after infection the control mice began to show four or five parasitized red cells per 1,000 red cells, whereas the cortisone-treated mice had eighteen to thirty-six infected cells per 1,000. The majority of the cortisone-treated mice, in seventy-two hours after infection, showed 300 per 1,000 red cells infected, whereas seven to eight days were required for the same level of parasitæmia to be attained in the control mice.

Death occurred in an average of just over five days in the cortisone-treated mice as against 9·5 days in the control mice. At death the spleens of cortisone-treated mice were smaller than those of control mice, suggesting that, as in other types of infection, the cellular reaction to infection was inhibited by the cortisone. Although results obtained in the mouse, which is highly susceptible to the effects of cortisone, cannot be directly transferred to man, these experiments suggest that cortisone may have to be used with caution in regions where malaria is prevalent.

Experiments with toxoplasma infections in mice also suggest that cortisone gives rise to a more fulminating infection than that seen in control mice.

Our thanks are due to Dr. P. C. C. Garnham for supplying the strains of *Plasmodium berghei* and *Toxoplasma*. The cortisone used in this work was provided from a generous gift made jointly to the Medical Research Council and the Nuffield Foundation by Merck and Co., Inc. One of us (G. M. F.) is in receipt of a grant for expenses from the Medical Research Council.

G. M. FINDLAY
E. M. HOWARD

Pharmacology Laboratories,
School of Pharmacy,
Bloomsbury Square,
London, W.C.1.
Dec. 20.

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Fructose as a Carbohydrate Constituent of Fertilizin from the Sand-dollar, *Echinarachnius parma*

Fertilizin, the sperm-agglutinating substance derived from the jelly-coat of the egg, has been regarded as playing a significant part in the fertilization process in a variety of animals[1,2]. Studies[3–4] of the chemical properties of fertilizin have shown that it belongs to that category of amino-acid- and sugar-containing substances termed glycoproteins or mucopolysaccharides. Many of the constituent amino-acids and sugars have been identified[5,6–9] in several species of echinoids. With regard to the carbohydrate components, galactose has been found in *Strongylocentrotus purpuratus*[5,6] and in *Echinus esculentus*[6], fucose in *Echinocardium cordatum*[8], and both these sugars in *S. draebachiensis* and *Paracentrotus lividus*[8]. While not implying that sugar composition is the main basis for the specificity of the fertilizin reaction, we wish to report the presence of fructose as the main monosaccharide derived from the egg-water of the sand-dollar, *Echinarachnius parma*.

Both acid sea-water extracts (*p*H 3·0) and ordinary sea-water extracts (*p*H 8·1) of the eggs of *Echinarachnius* proved satisfactory for a chromatographic analysis of the sugar present in fertilizin from the eggs of this species. Egg-water, after dialysis against running tap-water, was hydrolysed in a nitrogen atmosphere for 10–18 hr. with 6 *N* hydrochloric acid and concentrated to about one-tenth volume. Ascending unidimensional chromatograms of the hydrolysates were run at room temperature. Whatman No. 1 filter paper was used, with the upper (butanol) layer of mixtures of *n*-butanol, glacial acetic acid, and water in the volume ratios 5 : 1 : 5 and 4 : 1 : 5, as the irrigating solvents. Ammoniacal silver nitrate and aniline-phthalic acid in *n*-butanol were used as developing agents, and the paper dried at 105° C. Seven fertilizin hydrolysates were made, and all gave definite though weak spots. The low concentration is not surprising as the agglutination titre of the original sea-water extract was very weak. Unhydrolysed preparations and sea-water blanks gave no spots on the developed paper.

Sugar Chromatograms of Hydrolysed Fertilizin Extracts from the Sand-dollar, *Echinarachnius parma*

Source	R_F values	
Exp. *A*: Fertilizin extract 1	0·25	
" " 2	0·26	
" " 3	0·25	
Fucose	0·38	
Fructose	0·26	
Galactose	0·19	
Glucose	0·21	
Exp. *B*: Fertilizin extract 4	0·24	(0·09)
" " 5	0·25	
" " 6	0·23	
Fucose	0·31	
Fructose	0·23	
Galactose	0·17	
Fert. ext. 4 and fructose	0·24	(0·13)
" " 5 " "	0·19	(0·24 weak)
" " 6 " "	0·23	
Exp. *C*: Fertilizin extract 6	0·25	
" " 6	0·25	
Fucose	0·36	
Fructose	0·26	
Galactose	0·20	
Glucose	0·22	
Exp. *D*: Fertilizin extract 4	0·24	
" " 5	0·24	(weak)
" " 6	0·25	
Fucose	0·33	
Fructose	0·24	
Galactose	0·18	
Glucose	0·21	

The results show that hydrolysed fertilizin gives only one spot, corresponding to the R_F value for fructose (see table). A single spot was obtained when the fertilizin extract was added to fructose (Exp. *B*). In addition to fructose, one preparation (No. 4) gave another spot with a lower R_F value, indicating incomplete hydrolysis.

David W. Bishop
Charles B. Metz

Marine Biological Laboratory,
Woods Hole, Massachusetts. Oct. 1.

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Occurrence of the American Pondweed, *Potamogeton epihydrus* Raf., in the Hebrides

In August 1943, when I was dragging the lochs in the vicinity of Loch Eynort in the Isle of South Uist, Outer Hebrides, for pondweeds, there occurred in a backwater of Loch Ceann a'Bagh a very puzzling *Potamogeton* which, in its apparently sterile inflorescence, the paucity of its floating leaves and, in some plants, their total absence, strongly recalled × *Potamogeton billupsii* (= *P. coloratus* × *P. gramineus*), which I had discovered previously in Loch na Liane Moire in the neighbouring Isle of Benbecula. Nevertheless, the submersed leaves, in their general texture, lengths, breadths and parallel sides, were definitely against such an interpretation of the South Uist plant. Instead, they seemed to point clearly to a relationship with *P. polygonifolius* Pourr., or one of its hybrids. However, these ideas were in turn dispelled in 1944, when new and fruiting material was procured by Dr. W. A. Clark from a deep, peaty lochan draining into Loch Ceann a'Bagh. This enabled me to determine, with certainty, that both sets of plants belonged to the common American species *Potamogeton epihydrus* Raf. In this manner, not only was an important member added to the list of the American element in the British flora, but also a new species of pondweed placed on record for Europe.

Before we commenced our researches, this element was supposed to have its European headquarters in Ireland, although, so far as the Hebrides were concerned, it was recognized that *Najas flexilis* Rostk. et Schmidt and *Spiranthes stricta* (Ryd.) A. Nels. grew in the Isle of Colonsay, and *Eriocaulon septangulare* With. in the Isles of Skye and Coll. In the Inner Isles, our knowledge of such plants was extended in 1940 when my son Dr. J. Heslop Harrison discovered *Spiranthes stricta* in plenty on the Isle of Coll, and, in 1947, when I detected *Juncus tenuis* Willd. (undoubtedly as a genuine native) on the Isle of Tiree.

In the Outer Isles, while the presence of the freshwater sponge *Heteromyenia ryderi* Potts had been known for some time, the existence of the American element among the plants was first demonstrated in 1938 when I dredged *Najas flexilis* from Loch Altabrug in South Uist. Later, it was obtained from

many other lochs and lochans in the Isles of South Uist, North Uist and Benbecula. Among these was Loch Ollay, only six hundred yards from the nearest station for *P. epihydrus*.

After our earlier investigations, special visits were made to South Uist in 1949 and 1950 to study the general biology of the species. The first of these was carried out in spring to acquire information about the early developmental stages of the plant, and the other in autumn to carry out similar work on its general ecology, etc. On both of these occasions *P. epihydrus* was very abundant. Still, in view of the extreme biogeographical significance of the plant, it is to be hoped that botanists will spare it as much as possible in case it suffers the same fate as has befallen other Hebridean rarities.

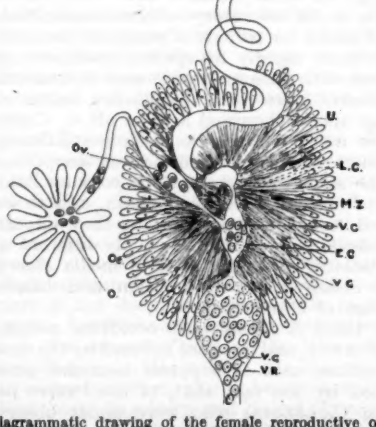
J. W. Heslop Harrison

King's College (University of Durham),
Newcastle upon Tyne 2. Nov. 26.

Female Reproductive System and Egg-shell Formation in *Fasciola hepatica* L.

An examination of serial sections of *Fasciola hepatica* shows that a narrow duct originates from the anterior end of the vitelline reservoir and runs for a short distance to open into a wide elliptical chamber situated in the central region of the shell gland (see diagram). According to Schubmann[1] and Stephenson[2], neither an ootype nor a receptaculum seminis is present in *Fasciola hepatica*, and, so far as I am aware, the presence of such a wide chamber has not previously been reported for this fluke. In order to distinguish the chamber from the ootype of other trematodes, I propose to call it the 'elliptical chamber'. In this chamber the vitelline granules, the vitelline cells and the oocytes are mixed together, and here the secretion of the shell gland is discharged and the egg-shell is formed.

Blumberg[3] and Sommer[4] held that the egg-shell of trematodes is formed from a secretion of the shell gland; but modern workers believe that it originates from globules or granules present within the vitelline cells[2,5,6]. Silver preparations (Aoyama, etc.) which I have examined reveal the presence of an extremely hyaline secretion present between the radiating protoplasmic strands of the medullary zone of the entire shell gland (see diagram). The secretion is light yellow in colour and exactly resembles the colour of the newly-formed egg-shell within the elliptical chamber. It is evident, therefore, that the gland secretes a hyaline fluid and that the fluid takes part in the formation of the shell.



Semi-diagrammatic drawing of the female reproductive organs of *Fasciola hepatica*. *E.C.*, elliptical chamber; *L.C.*, Laurer's canal; *M.Z.*, medullary zone; *O.*, ovary; *Oc.*, oocyte; *Ov.*, oviduct; *U.*, uterus; *V.C.*, vitelline cell; *V.G.*, vitelline granules; *V.R.*, vitelline reservoir

Immediately after the vitelline cells enter the vitelline reservoir they begin to discharge granules. The egg-shell is later reinforced temporarily from the inside by the vitelline granules; the latter ultimately serve as nutriment for the developing egg. Additional evidence in support of this interpretation was produced by an examination of torn eggs, situated within the lower part of the uterus, where a layer of vitelline granules was clearly visible lying inside the outer shell.

In view of the present findings, I believe that the suggestion of some workers for the substitution of the term 'Mehlis's gland' for 'shell gland' is not desirable.

It is hoped shortly to publish a fuller account of this work. I would like to express my thanks to Prof. R. A. R. Gresson for guidance during the course of the investigation.

H. K. Yosufzai

Department of Zoology,
Queen's University,
Belfast. Nov. 8.

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A New Method for the Demonstration of the Golgi Material

For the demonstration of the Golgi material in animal cells by the formalin silver nitrate method, Cajal's uranium nitrate[1], Da Fano's cobalt nitrate[2,3] and Aoyama's cadmium chloride[4] techniques are employed. As a result of careful experiments, I have found that the following new fixative gives very good results: cupric chloride (1 per cent in distilled water), 85 c.c.; neutral formol, 15 c.c.

The cupric chloride solution should be prepared separately and the neutral formol added just before use. Fix small pieces of fresh tissue for 2–4 hr. at about 20° C. Rinse quickly in two changes of distilled water, transfer to a freshly prepared 1·5 per cent solution of silver nitrate and keep in the dark for 8–24 hr. at about 20° C. The optimum time for the silver bath varies considerably for different animals and for different tissues from the same animal, and therefore must be determined experimentally. As a rule, the tissues of warm-blooded animals require less time in the silver bath than do those of poikilothermous animals. Rinse quickly in two changes of distilled water, transfer to a freshly prepared reducing solution (hydroquinone 1 gm., sodium sulphite 1·5 gm., neutral formol 15 c.c., distilled water 85 c.c.) and keep in the dark for about six hours. I find that ordinary sodium sulphite crystals are very satisfactory and that it is not necessary to use anhydrous sodium sulphite as recommended by some authors. Wash for about half an hour in running water. Cut frozen sections, or alternatively bring up to absolute alcohol and clear in cedar-wood oil, embed in paraffin wax. Sections may be toned with gold chloride and

stained in a similar manner to material prepared by the other silver techniques.

Overfixation is liable to bring about impregnation of the mitochondria and other inclusions as well as of the Golgi material. I have consistently used lithium carbonate to neutralize the formol; but I believe that any of the usual neutralizing agents would be equally suitable for the purpose.

I have successfully used this method to prepare mammalian tissues and the tissues of annelids, molluscs and insects. Referring to Aoyama's method, Gatenby and Beams[5] remark: "After having seen preparations of various vertebrate and invertebrate tissues made by this method, we have concluded that it is the best of the three formalin silver methods and the nearest approach to a good osmic Golgi technique". I find that preparations made with my cupric chloride formol method are not only as good as those prepared by Aoyama's method, but in many cases, chiefly in toned sections, the general appearance is superior. Cupric chloride has a slight advantage over cadmium chloride in being more easily available.

Like Aoyama's method, my technique is a modification of Cajal's formalin silver nitrate method. Cajal[1] originally suggested other nitrates such as those of manganese and lead, but these were found to be unsatisfactory. Da Fano[2] experimented with other salts, for example, cobalt sulphate and copper nitrate, but these did not give satisfactory results. I have tried different percentages of cupric chloride solution, but find that 1 per cent gives the best results. I have also treated tissues with saturated solution of cuprous chloride (its solubility in water is less than 0·5 per cent), but the preparations were inferior to those treated with cupric chloride.

I wish to thank Prof. R. A. R. Gresson for providing facilities for this work and for advice and encouragement.

D. S. Srivastava

Department of Zoology,
Queen's University, Belfast.
Oct. 29.

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Detoxifying Mechanisms in Clothes Moth Larvæ

Larvæ of the clothes moth, *Tineola bisselliella* (Humm.), are able to develop on woollen fabric impregnated with many of the inorganic poisons which are highly toxic to insects and other animals.

Salts of those metals capable of producing insoluble sulphides result in the formation of characteristically coloured sulphides in the food undergoing digestion in the midgut. The alkaline (*p*H 10), highly-reducing (about −300 mV.) midgut digestive juices[1,2] reduce the disulphide bonds of the cystine of wool (present to the extent of about 13 per cent), and sulphydryl groups and hydrogen sulphide are formed. Sulphides are formed by reaction of metal ions with these groups. Larvæ fed on metal-impregnated silk (which contains no sulphur) do not produce sulphides unless a sulphur-containing material (such as cystine, methionine, or glutathione) is added to the diet. This detoxifying mechanism is reminiscent of the protection given by 2.3-dimercapto propanol (BAL) against poisoning by arsenic and a number of other metals[3].

When a sulphide-forming metal is present in the diet, less cystine is excreted than on a metal-free diet. Most of the metal sulphide formed is excreted. However, a small amount forms a colloidal solution with the amino-acids or polypeptides liberated by digestion of the food or present in the digestive secretions. Sulphides are then taken up by the midgut epithelium and accumulated in the cavities of the goblet cells (hitherto of unknown function) in the anterior and posterior regions until the following moult, when the entire midgut epithelium is cast off and regenerated.

A number of elements are incapable of forming insoluble sulphides under the conditions existing in the digestive tract. Of these, the alkaline earths are deposited, initially as insoluble phosphates, in the columnar cells of the anterior and posterior midgut. It is probable, also, that small quantities of absorbed fluoride are deposited with calcium in these granules.

Fuller details of the poisons used and the detoxifying mechanisms involved will be published elsewhere[3].

D. F. Waterhouse

Division of Entomology,
Commonwealth Scientific and
Industrial Research Organization,
Canberra. Oct. 30.

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Natural Occurrence of Rough Variant of a Yeast, *Candida albicans*

In the course of an investigation by Dr. M. J. Marples, of this Department, and myself upon the effects of antibiotics upon the yeast flora of the mouth, *R* colonies of *Candida albicans* have been found upon repeated occasions on primary cultures which had been incubated at 37° C. for two days. The occurrence of dissociated, rough variants of *Candida albicans*, which show a reduced pathogenicity to rabbits, has been noted in the literature since 1935. To our knowledge all these variants have been reported as occurring in old laboratory cultures maintained upon artificial media for periods of years, or else have been induced more rapidly by special conditions such as treatment with immune serum and lithium chloride. Our cultures were made by plating saline mouth-washings upon Sabouraud agar of *p*H 4. Continuous variation was observed, from colonies differing only by a central depression from normal smooth colonies upon the same plate, to smooth colonies haloed by a ring of mycelium in the medium, and to colonies so raised, rough and warty that they appeared to be, on casual inspection, of a wholly different species. These isolates upon appropriate media showed the typical chlamydospore formation and biochemical characters of *C. albicans*.

That these *R* forms were occurring naturally in the oral cavity, and were not induced by the unusually acid medium used to suppress bacterial growth, is suggested by the fact that, of the twelve patients carrying *C. albicans* who were under observation, only four produced *R* variants, and that these appeared in small numbers upon repeated cultures. Further, Langeron and Guerra[1] regard an excessively

alkaline medium as promoting the rough variants and an acid one the smooth.

Saline mouth-washings were then taken from a hundred normal adults and cultured in the same way as those from patients. Forty-six of these adults were found to carry *C. albicans*, and rough colonies appeared in six of these forty-six positive cultures.

Work is at present in progress upon the effects of *R*, *S* and intermediate strains when injected intravenously into rabbits. Results so far closely parallel those of Mackinnon[2]. From these results it already appears that the lessening pathogenicity of the yeast as it progresses towards the *R* form is not due directly to the increasingly larger proportions of pieces of mycelium in the culture suspensions as the shift is made from smooth to rough. Possibly a change in structure, or absence, of a capsule may be the cause of the diminution of pathogenicity. If this is so, capsular staining techniques upon smears of material taken directly from the mouth may show whether the *R* forms actually occur in the mouth or whether some individuals carry smooth strains of so unstable a nature that they dissociate immediately upon culture on artificial media.

Agglutinating sera from rabbits which had received a single, sub-lethal dose of *R* strains gave positive results against *S* strains at a level of 1 : 1,250 fourteen days after injection. Benham[3] was able to prepare antisera against *C. albicans* to a level of 1:1,000 with killed suspensions of *S* strains, but only by multiple injections over a period of four weeks. It would appear that the method described here is a more rapid and satisfactory way of obtaining immune sera.

M. E. DI MENNA

Medical Mycology Unit,
Department of Bacteriology,
Medical School, University of Otago. Oct. 24.

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Strains in the Mollusc *Potamopyrgus jenkinsi* (Smith)

RECENTLY, Continental workers have published papers dealing with various aspects of the parthenogenetic mollusc *Potamopyrgus jenkinsi* (Smith). Boettger[1,2] discusses the cause of the keel on the shell and the systematics of the snail; Bondesen and Kaiser[3] deal mostly with its ecology in Denmark. A preliminary summary is given here of observations I have carried out on this mollusc during the past six years.

In Great Britain, and probably also on the Continent, *P. jenkinsi* is represented by a number of strains which differ from one another phenotypically and genetically. Earlier experiments[4] had already suggested this. Populations may consist of only one strain; but quite often two or three strains may live side by side. The commonest major strain (strain *A*) has a shell as figured by Ellis[5]. The shell is slender, the suture is not deep, and the mantle pigment is rather pale. Another common major strain was first noticed in the estuarine part of the River Hamble at Botley, Hants, in March 1943. It has since been found in many localities, mainly brackish water, but also inland ones. Bondesen and Kaiser figure it from Danish brackish-water localities, without commenting on its significance. In this strain the whorls are convex and the suture is correspondingly deeper, the shell is less slender and the mantle surface is deeply pigmented. This strain can be distinguished at an early age from the slender type; it grows more slowly and usually does not reach such a large size. It also differs physiologically, being more sensitive to adverse conditions and apparently less prolific. In the St. Bride's Bay area of Pembrokeshire is a rather small-sized strain (strain *C*) with very pale or patchy mantle pigmentation. This strain, even more than strains *A* and *B*, shows sub-strains in nearby localities in the same area. The cause of the keel sometimes present as an ornamentation on the shell of this snail has attracted the attention of Robson[6], Boycott[7], Warwick[4], and Boettger[2]. Robson's results were entirely negative; Boycott thought 'bad' conditions might cause the keel, while Boettger, on the contrary, suggested that optimal conditions, especially good aeration, might be responsible. The percentage of individuals in a population depends on a complexity of factors. Keel production is partly genetically determined by the strain to which the parent snail belongs. Thus, most of strains *A* and *B*, but not all, will either give one hundred per cent smooth offspring or only a low percentage of keeled offspring in the laboratory, whether or not the wild parent was keeled or smooth. It is obviously difficult to reproduce a 'keel-inducing' environment in the laboratory. Strain *C* may, however, give one hundred per cent keeled offspring in some laboratory conditions and a lower percentage in others.

Many experiments have been performed with broods derived from one original wild parent of strain *A* isolated from a population which has been one hundred per cent smooth for many years at Kirkcaldy, Fife. In this way it has been found that both common and trace inorganic constituents of natural waters have no direct effect on keel production. Excess plant organic matter neither causes the keel, nor does it inhibit its formation. Good aeration from birth has no keeling effect in brackish or fresh water. Snails in the laboratory often grow to a larger size than their wild parents, indicating optimal conditions, but such snails are usually smooth.

Two series of experiments, each of twenty-two aquaria, were set up, using broods from one original Kirkcaldy snail. Water used in both series was the same; in the first series, however, the algæ supplied as food were from a lake at Kirkcaldy; in the second series they were from a stream at Pencaitland, East Lothian. In the first series 2 snails out of 291 were keeled, in the second series 46 out of 303 were keeled. Experiments so far indicate that the algal and not the bacterial part of the flora induces growth of the keel. This result was foreshadowed by early experiments[4]. The algal metabolites which induce the keel can be carried in the water, and experiments indicate that they are present in stream water in summer but are found in small quantity, if at all, in winter. Also, they are present in smaller quantity in the headwaters of streams. Variation may be shown by members of a brood of offspring of one original parent born at the same time and reared in the same aquarium. Some may be smooth and others may show keels of varying strengths.

One strain of *P. jenkinsi* behaves differently from all the rest. This strain is, from shell shape and general pigmentation, a type of strain *B*; it is very aculeate and is limited to a tiny locality in Hampshire. In all laboratory conditions so far it has given aculeate offspring. It is, however, unstable genetically, giving rise to an occasional perfectly smooth or

weakly keeled snail which breeds true. The rate of change from aculeate to smooth, though small, is much higher than that of mutation-rates in general.

The keel in *P. jenkinsi* is produced by a small blunt lobe of the mantle edge which is most conspicuous in aculeate snails.

T. Warwick

Royal (Dick) School of Veterinary Studies,
University of Edinburgh. Jan. 10.

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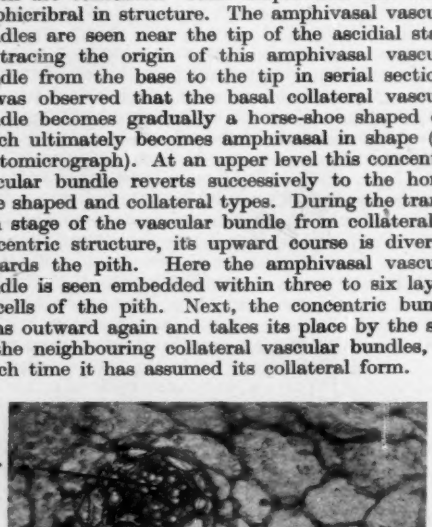
Concentric Vascular Bundle in some Ascidial Stalks of *Clerodendron infortunatum* Gaertn.

Some ascidial stalks of *Clerodendron infortunatum* described earlier[1] contain a few vascular bundles which are concentric—some amphivasal and others amphicribral in structure. The amphivasal vascular bundles are seen near the tip of the ascidial stalk. In tracing the origin of this amphivasal vascular bundle from the base to the tip in serial sections, it was observed that the basal collateral vascular bundle becomes gradually a horse-shoe shaped one which ultimately becomes amphivasal in shape (see photomicrograph). At an upper level this concentric vascular bundle reverts successively to the horse-shoe shaped and collateral types. During the transition stage of the vascular bundle from collateral to concentric structure, its upward course is diverted towards the pith. Here the amphivasal vascular bundle is seen embedded within three to six layers of cells of the pith. Next, the concentric bundle turns outward again and takes its place by the side of the neighbouring collateral vascular bundles, by which time it has assumed its collateral form.



Photomicrograph of an amphivasal vascular bundle. × *c.* 150. *ph.*, phloem; *x.*, xylem

The second type of concentric vascular bundle, namely, the amphicribral one, is found near the end of the ascidial stalk, where the bundles are mostly partially or rarely completely concentric. In the petiole of many plants such amphicribral vascular bundles have been noted by Eames and MacDaniels[2], Metcalfe and Chalk[3] and Solereder[4].

The leaf-trace bundles of many monocotyledonous rhizomes and the medullary strands of some dicotyledonous plants are amphivasal[5]. Arber[6] recorded its occurrence, among others, in the foliage leaves of some monocotyledonous plants. It does not appear to have been recorded before in the petiole of *Clerodendron*. Fuller details will be published elsewhere.

I wish to express my thanks and appreciation to Dr. D. M. Bose, director, and to Dr. K. T. Jacob, head of the Department of Botany, of the Bose Institute, for their interest and the latter's helpful criticism in this work.

D. N. Chakraverti

Botany Department, Bose Institute,
93 Upper Circular Road,
Calcutta 9. Oct. 6.

[1] Chakraverti, D. N., *Curr. Sci.*, **20**, 48 (1951).
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Transmission of a Nuttallia of a Gerbil by *Rhipicephalus sanguineus*

For some years we have been searching for piroplasms among those local rodents which can be bred in the laboratory. Success in this direction would obviously facilitate work on piroplasmosis and would also provide convenient material for chemotherapeutic studies.

A Nuttallia found in a gerbil, *Meriones tristrami*, is the nearest approach we have made so far in this direction. This Nuttallia is non-pathogenic for normal animals but becomes pathogenic, though rarely fatal, in splenectomized animals. After splenectomy the parasites multiply until almost 90 per cent of the red cells are infected. The infection becomes chronic with exacerbations of high parasitæmia at various intervals. We have not seen spontaneous cure in animals observed for twelve months. Unfortunately, this piroplasm is not infective for other laboratory animals (very rarely a transient infection is produced in splenectomized mice). This, however, is no great drawback since *Meriones tristrami* can be bred in the laboratory.

This Nuttallia is readily transmitted by inoculation of whole blood. We have also transmitted it by nymphs of *Rhipicephalus sanguineus* reared in the laboratory and fed as larvæ on infected animals. It is interesting to note that *Rhipicephalus sanguineus*, which has been employed extensively in experimental transmission of piroplasms of domestic animals, of *Hepatozoon canis* and rickettsias of man and animals, really contains two distinct species readily distinguished by the characters of the larvæ and nymphs and the genital aperture of the female. This finding necessitates a revision of some of the accepted data on the transmission of a number of important pathogens.

We may add that *Meriones tristrami* is frequently parasitized by a *Grahamella*, which we have transmitted in the laboratory by *Hæmaphysalis otophila*.

This work was carried out with the aid of a grant from the Research Council of Israel.

S. Adler
Brouria Feldman-Muhsam

Department of Parasitology,
Hebrew University,
Jerusalem.
Oct. 19.

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, March 31

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Prof. S. W. Wooldridge: "The Changing Physical Landscape".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "Statistics as applied to Engineering" (to be opened by Mr. W. A. Carne).

Tuesday, April 1

INSTITUTION OF CHEMICAL ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 2.30 p.m.—Symposium on "Simplification in Stainless Steel Specifications".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "The Specification and Measurement of Performance in Servo Systems" (to be opened by Prof. A. Tustin and Mr. J. F. Coales).

SOCIETY OF CHEMICAL INDUSTRY, CROP PROTECTION PANEL of the AGRICULTURE GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Annual General Meeting; Dr. D. L. Gunn: "Locusts".

Wednesday, April 2

ROYAL SANITARY INSTITUTE (at 90 Buckingham Palace Road, London, S.W.1), at 2.30 p.m.—Dr. B. A. Southgate and Mr. W. S. Preddy: "Discharge of Sewage and Industrial Wastes to Estuaries".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. C. P. Norbury: "Modern Developments in Fruit Farming".

TELEVISION SOCIETY (joint meeting with the BRITISH KINE SOCIETY, at Film House, Wardour Street, London, W.1), at 6.45 p.m.—Mr. W. D. Kemp: "A New Television Recording Camera".

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Scientific Papers.

Wednesday, April 2—Friday, April 4

INSTITUTION OF NAVAL ARCHITECTS (on board the Headquarters Ship *Wellington*, Honourable Company of Master Mariners, Victoria Embankment, London, W.C.2).—Spring Meeting.

Thursday, April 3

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. D. H. Parry: "A Logical Approach to the Problems of Electric Space-Warming".

PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 5.30 p.m.—Dr. L. L. Katan: "The Theory and Use of Vacuum-Powder Thermal Insulation at Low Temperatures".

BRITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Discussion on "V.H.F. and U.H.F. Broadcasting" (to be opened by Mr. P. Adorian).

Thursday, April 3—Tuesday, April 8

PHYSICAL SOCIETY (at the Imperial College, Imperial Institute Road, London, S.W.7), at 10 a.m. each day.—Exhibition.

Friday, April 4

EUGENICS SOCIETY (at Manson House, 26 Portland Place, London, W.1), at 5 p.m.—Dr. J. A. Fraser Roberts: "The Genetics of Mental Deficiency" (Galton Lecture).*

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. E. C. Bullard, F.R.S.: "The Interior of the Earth".

Friday, April 4—Saturday, April 5

BOTANICAL SOCIETY OF THE BRITISH ISLES (at the Royal Horticultural Society's New Hall, Greycoat Street, London, S.W.1), at 10.30 a.m. each day.—Conference on "The Changing Flora of Britain".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT (Grade B) IN CHEMISTRY—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (April 5).

ASSISTANT LECTURER IN PHYSICS—The Registrar, King's College, Strand, London, W.C.2 (April 5).

CIVIL ENGINEER at Divisional Production Headquarters, Ystrad Mynach, Hengoed, Glamorgan—The Divisional Establishment Officer, National Coal Board, South-Western Division, Cambrian Buildings, Mount Stuart Square, Cardiff (April 5).

JUNIOR CHEMISTS in the Central Laboratory, Chiswick—The Staff Officer (F./EV.203), London Transport, 55 Broadway, London, S.W.1 (April 5).

SCIENTIST, Grade II, in the No. 4 (Burnley) Area Laboratory at Altham Coke Works, Altham, Accrington—The Divisional Establishment Officer, National Coal Board, North-Western Division, 40 Portland Street, Manchester 1 (April 5).

SUPERINTENDING SCIENTIST IN THE RESEARCH AND DEVELOPMENT BRANCH, to direct the work of the Chemical and Physical Research Laboratories in Melbourne involving the planning, co-ordination and execution of a wide variety of research projects bearing on defence problems—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (April 7).

LECTURERS (with a University degree in either metallurgy, chemistry or chemical engineering, and with experience in industry) IN THE DEPARTMENT OF CHEMICAL ENGINEERING, University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (April 14).

ASSISTANT LECTURERS IN PHYSICS—The Registrar, The University, Manchester 13 (April 19).

CHAIR OF AGRICULTURE at University College, Ibadan, Nigeria—, The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (April 19).

KEDDEY-FLETCHER-WARR STUDENTSHIP for the promotion of post-graduate research in the Faculty of Science—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 19).

LECTURER IN MINING in the Post-Graduate School of Mining, a LECTURER IN MINING in the Department of Mining, and a DEMONSTRATOR in the University Post-Graduate School of Mining—The Registrar, The University, Sheffield (April 19).

RESEARCH FELLOWSHIP IN SCIENCE—The Secretary, The University, 38 North Bailey, Durham (April 19).

RESEARCH ASSISTANT IN THE DEPARTMENT OF APPLIED MATHEMATICS, for theoretical work on upper atmospheric physics—The Professor of Applied Mathematics, Queen's University, Belfast (April 20).

ASSISTANT LECTURER (graduate in physics, chemistry, biology or engineering) IN DENTAL MATERIALS—The Registrar, The University, Manchester 13 (April 30).

ASSISTANT LECTURER IN STATISTICS in the Faculty of Commerce and Social Science—The Secretary, The University, Birmingham 3 (April 30).

HEAD OF THE BOTANY DEPARTMENT—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (April 30).

LECTURER IN CHEMISTRY at Rhodes University, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (April 30).

LECTURER IN PHYSICS (preferably with a specialist knowledge of theoretical physics), a LECTURER or ASSISTANT LECTURER IN COMPARATIVE PHYSIOLOGY, and an ASSISTANT LECTURER IN ZOOLOGY—The Secretary and Registrar, University College of North Wales, Bangor (April 30).

LECTURER IN THE DEPARTMENT OF ZOOLOGY—The Secretary, University College, Gower Street, London, W.C.1 (April 30).

PRINCIPAL—The Registrar, Municipal Technical College, Portsmouth (April 30).

ENGLISH ELECTRIC COMPANY RESEARCH FELLOWSHIP for post-graduate research into problems of vibration stability or control of aircraft—The Registrar, College of Aeronautics, Cranfield, Bletchley, Bucks (May 1).

LECTURERS and ASSISTANTS IN EXPERIMENTAL or THEORETICAL PHYSICS—The Secretary, The University, Aberdeen (May 1).

WELLCOME CHAIR OF CLINICAL TROPICAL MEDICINE at the London School of Hygiene and Tropical Medicine—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 1).

UNIVERSITY LECTURERS or UNIVERSITY DEMONSTRATORS (to teach in some of the following subjects: Applied Mechanics, Mechanics of Machines, Fluid Mechanics, Thermodynamics and Heat Engines, Theory of Structures, Strength and Properties of Materials, Aerodynamics, Electricity)—The Secretary of the Appointments Committee, Engineering Laboratory, Cambridge (May 15).

READER or SENIOR LECTURER IN PHYSIOLOGY at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 24).

ASSISTANT EXPERIMENTAL OFFICERS to help with research work mainly on the composition of milk, milk products and animal feeding-stuffs—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 52/3.

BACTERIOLOGIST with knowledge of bacterial chemistry, and a BIOCHEMIST with knowledge of bacteriology—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 52/5.

BIOCHEMIST (Principal Grade), and a SENIOR ASSISTANT BIOCHEMIST (Senior Grade), IN THE DEPARTMENT OF BIOCHEMISTRY (Research)—The Secretary, Christie Hospital and Holt Radium Institute, Manchester 20.

BIOLOGIST IN THE GAME DEPARTMENT, Tanganyika, to study the life-histories and habits of crop-destroying mammals and birds (vermin) with a view to evolving effective control measures, etc.—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. 27219/3.

CHEMICAL ENGINEER for investigations on various aspects of whiting manufacture, including classification of powders by wet and dry processes, drying processes, and general handling of suspensions and powders—The Director of Research, Research Council of the British Whiting Federation, 245 Ampthill Road, Bedford.

EXPERIMENTAL OFFICER for performance testing of dairy machinery—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 52/4.

FIELD ZOOLOGIST (with a University degree in zoology and a sound knowledge of entomology and botany or of agriculture) in Kenya, to undertake survey work of tsetse distribution, to make ecological studies of tsetse control and to take part in the general advisory work of the Veterinary Department—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. 27066/12.

GRADUATES IN CHEMISTRY for scientific posts in the Cannock Chase and South Staffs areas—The Divisional Establishment Officer, National Coal Board, Himley Hall, Dudley, Worcs.

HYDRO-ELECTRIC ENGINEERING CONSULTANT for the Thal Development Authority, Punjab Province, Pakistan, under the Commonwealth Technical Co-operation Scheme for South and South-East Asia—The

Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.477/51-0.

Lecturer (with a university degree in engineering, or equivalent qualification, and practical experience in the electrical industry) in the Electrical Engineering Department—The Secretary, Northampton Polytechnic, St. John Street, London, E.C.1.

Lecturer in Electrical Engineering at Bradford Technical College—The Director of Education, Town Hall, Bradford.

Lecturer in the Department of Mathematics—The Secretary, Royal Technical College, Glasgow.

Lecturer (Grade IIa) in the Physics Department—The Principal, Paisley Technical College, Paisley.

Physicist (with a good honours degree; an interest in statistical methods is desirable) for work concerned initially with the processing of textile fibres both from a practical and theoretical point of view—The Secretary, British Jute Trade Research Association, Kinnoull Road, Kingsway West, Dundee.

Scientific Officer (with a University degree or an equivalent professional qualification, and experience in chemical engineering and fuel technology) under the East African Industrial Research Board—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. 27106/55/52.

Senior Experimental Officer at the Hydraulics Research Station, Wallingford, Berks, to take charge of small team engaged on hydrographic surveying of beaches and estuaries and the movements of beach materials by waves and currents—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting E.89/52A.

Senior Lecturer in Chemical Engineering—The Principal, West Ham Municipal College, Romford Road, Stratford, London, E.15.

Senior Lecturer to take charge of physics teaching to the B.Sc. special degree—The Clerk to the Governors, South-West Essex Technical College and School of Art, Forest Road, Walthamstow, London, E.17.

Senior Research Officer to direct a team of professional (Ph.D.) and technical personnel engaged in fundamental and applied work in the field of fats and oils, a Biometrician for consultation and independent theoretical and applied research on problems encountered in laboratory experimentation, and a Biophysicist to undertake research involving the application of physics to biological material, preferably in the development of ultra-violet, infra-red and electron microscope techniques for the examination of cells, or in the application of tracer or other methods for determining the internal cell composition and membrane permeability of individual cells such as halophilic bacteria—The Director, Division of Biology, National Research Council, Ottawa, Ont., Canada.

Soil Conservation Officer to serve under the Director of Agriculture, Ceylon—The Ministry of Labour and National Service, Technical and Scientific Register (A.8.12), Almack House, 26 King Street, London, S.W.1, quoting A.12/C.172.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Scottish Home Department. Freshwater and Salmon Fisheries Research, 2: Second Annual Report of the Supervisory Committee for Brown Trout Research, 1949–1950. Pp. 12+4 plates. (Edinburgh and London: H.M. Stationery Office, 1951.) 2s. 6d. net. [2012

Transactions of the Royal Society of Edinburgh. Vol. 62, Part 1, No. 6: On the Carboniferous Nautiloids, *Orthoceras gigantea* J. Sowerby and allied Forms. By J. Selwyn Turner. Pp. 169–190+8 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1951.) 11s. [81

Third Cape Catalogue of Stars for the Equinox of 1925·0. Catalogue of 6597 Stars between the Equator and Declination −30° compiled from Observations made with the Reversible Transit Circle at the Royal Observatory, Cape of Good Hope, in the Years 1932–1936 under the direction of Dr. J. Jackson. Pp. xviii+132. (London: H.M. Stationery Office, 1950.) 15s. net. [81

Advances in Physics: a Quarterly Supplement of the Philosophical Magazine. Vol. 1, No. 1, January. Pp. iv+110. (London: Taylor and Francis, Ltd., 1952.) 15s.; per annum, 55s. [81

Science Museum. Handbook of the King George III Collection of Scientific Instruments. By J. A. Chaldecott. Pp. 92+8 plates. (London: H.M. Stationery Office, 1951.) 7s. 6d. net. [81

Scientific Proceedings of the Royal Dublin Society. Vol. 25 (N.S.), No. 23: The Theory of the Use of Alpha Ray Ranges in Nuclear Emulsions for the Determination of the Radioactive Contents of Materials. By J. H. J. Poole and C. M. E. Matthews. Pp. 305–316. (Dublin: Royal Dublin Society, 1951.) 2s. [81

Royal Institute of Chemistry. Lectures, Monographs and Reports 1951, No. 3: One Hundred Years of Chemistry. By the Lord McGowan. (Seventh Dalton Lecture.) Pp. 16. (London: Royal Institute of Chemistry, 1951.) 3s. net. [81

British Mycological Society. Transactions. Fifty Year Index (1896–1946, Vols. 1–30.) Compiled by G. R. Bisby. Pp. v+126. (Cambridge: At the University Press, 1951.) 21s. [81

Air Ministry: Meteorological Office. Meteorological Reports, No. 9: Ice Accretion on Aircraft. (M.O 535d—A.P. 3264.) Pp. iii+36. (London: H.M. Stationery Office, 1951.) 1s. 9d. net. [81

Medical Research Council. Special Report Series No. 273: Infective Hepatitis; Studies in East Anglia during the Period 1943–47. By Dr. F. O. MacCallum, A. M. McFarlan, J. A. R. Miles, M. R. Pollock and C. Wilson. Pp. vi+144. (London: H.M. Stationery Office, 1951.) 4s. 6d. net. [81

British Cotton Industry Research Association. Shirley Institute Year Book. Pp. 125. (Manchester: British Cotton Industry Research Association, 1951.) [81

Communications of the Dublin Institute for Advanced Studies, Series A, No. 8: Studies in the Generalized Theory of Gravitation. 2. The Velocity of Light. By O. Hittmair and E. Schrödinger. Pp. 15. (Dublin: Dublin Institute for Advanced Studies, 1951.) [81

Microscopic Staining Techniques. No. 3. Compiled and edited by Edward Gurr. Pp. 64. (London: Edward Gurr, Ltd., 1951.) 3s. 6d. [81

Metropolitan Water Board. Thirty-fourth Report on the Results of the Bacteriological, Chemical and Biological Examination of the London Waters for the Years 1939–1946. By Lieut.-Colonel E. F. W. Mackenzie. Pp. 102+10 plates. (London: Staples Press, Ltd., 1951.) 15s. 6d. [81

Bulletin of the British Museum (Natural History). Entomology. Vol. 2, No. 2: A Revision of the Australian and Tasmanian Gripopterygidæ and Nemouridæ (Plecoptera). By D. E. Kimmins. Pp. 43–63. (London: British Museum (Natural History), 1951.) 10s. [81

Ministry of Agriculture and Fisheries. Fishery Investigations, Series 1, Vol. 5, No. 5: Salmon Studies 1950. By Dr. J. W. Jones. Pp. 12. (London: H.M. Stationery Office, 1951.) 1s. net. [81

Linen Industry Research Association. Report of the Council, 1951. Pp. 20. (Lambeg, Co. Antrim: Linen Industry Research Association, 1951.) [81

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 631, Vol. 236: A Contribution to the Study of the Eocene in Western Pakistan and Western India. C, The Description of the Scaphopoda and Gastropoda from Standard Sections in the Rakhi Nala and Zinda Pir Areas of the Western Punjab and in the Kohat District. By F. E. Eames. Pp. 168+6 plates. (London: Cambridge University Press, 1952.) 46s. [81

Nationalised Industry Series, 9: Patterns of Organisation. Pp. iii+32. (Claygate: Acton Society Trust, 1951.) 2s. [81

British Standard Mechanical Tests for Metals (excluding Welds). B.S. Handbook No. 13. Pp. iv+243. (London: British Standards Institution, 1951.) 17s. 6d. net. [91

General Register Office. The Registrar General's Quarterly Return for England and Wales. No. 411: Births Deaths and Marriages, Infectious Diseases, Weather, Survey of Sickness, Population Estimates; Quarter ended 30th September 1951. Pp. 32. (London: H.M. Stationery Office, 1951.) 2s. 6d. net. [141

Other Countries

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